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

MAMF Scope Summary and Introduction

This standard of practice contains procedures, minimum requirements and general guidance for measurement of radon in buildings having more than one attached dwelling or other occupied unit that were under the same ownership or designated maintenance or management authority for the purpose of determining if radon mitigation is necessary in order to protect current or future occupants. These protocols address testing in multifamily structures that can include those with shared ownership or maintenance such as co-op units, townhouses, condominiums or vacation timeshare properties and structures, or a portion thereof that are used, for example, as apartment houses, dormitories, military congregate residences, fraternities and sororities, nontransient boarding houses, hotels, convents, monasteries, motels and live/work units. These protocols also address testing a single dwelling within a multifamily building.

Included are informational pages for an “Introduction to Radon” and an “MAMF Companion Guidance” document for aiding residence managers, citizens and professionals.

Significance of Purpose

Radon is the second leading cause of lung cancer in the general population and the leading cause of lung cancer among nonsmokers.¹ Most people receive their greatest exposure to radon in their home or dwelling. Radon concentrations in ground-contact apartments have been found to be similar to those in low-rise residential buildings located in the same area.² Radon in homes and dwellings is the cause of approximately 21,000 U.S. lung cancer deaths each year.³ This risk is largely preventable.

Significance of Use

This document contains protocols and guidance designed to respond to the health threat of radon in dwellings in multifamily buildings. This standard addresses the needs of citizens, radon measurement professionals, property owners, residence/facility managers, consultants, manufacturers and regulators concerned with radon measurements in multifamily buildings.

Applicability

If the minimum requirements of this document exceed local, state or federal requirements for the locale in which the radon test is conducted, then this document’s minimum requirements should be followed. These guidelines can be adopted as part of a state program or can be provided as recommendations by states to testing companies and interested individuals. AARST recommends that any authority or jurisdiction that is considering substantial modifications of this document as a condition of its use seek consensus within the consortium process at AARST Consortium on National Radon Standards prior to adopting a modified version. This provides the jurisdiction with a higher degree of expertise and an opportunity for the Consortium on National Radon Standards to update its document if appropriate.

Historical Perspective on Radon

Since 1988, the Indoor Radon Abatement Act has authorized U.S. state and federal activities to reduce citizen risk of lung cancer caused by indoor radon concentrations. Since the early 1990s, the U.S. Environmental Protection Agency (EPA) has advised all U.S. schools to test for radon and to reduce levels to below 4 pCi/L.³

In 1999, the National Academy of Sciences confirmed that any exposure to radon holds a degree of risk with publication of BEIR VI.¹ In addition, the Academy’s BEIR VII committee stated that exposure to radiation, including any concentration of radon, carries risk.

In 2009, the World Health Organization’s WHO Handbook on Indoor Radon confirmed the association between indoor radon exposure and lung cancer, even at the relatively low radon levels found in residential buildings.¹

Initiated in 2010, the U.S. Federal Radon Action Plan (FRAP), followed by the National Radon Action Plan (NRAP), has highlighted an ultimate public health goal of eliminating preventable radon-induced cancer. The FRAP is the result of a collaborative effort led by EPA with the U.S. Departments of Health and Human Services (HHS), Agriculture (USDA), Defense (DOD), Energy (DOE), Housing and Urban Development (HUD), Interior (DOI), Veterans Affairs (VA) and the General Services Administration (GSA). And the NRAP, led by the American Lung Association, represents a collaborative effort between several federal and national organizations including AARST and the Conference of Radon Control Program Directors (CRCPD).

Development and Maintenance of this Standard

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

This standard is under continuous maintenance by the AARST Consortium on National Radon Standards for which the Executive Stakeholder Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form and instructions may be obtained in electronic form at www.radonstandards.us.

¹ World Health Organization, “WHO Handbook on Indoor Radon: A Public Health Perspective” 2009
³ National Academy of Sciences, “Biological Effects of Ionizing Radiation” (BEIR VI Report) 1999
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Notice of right to appeal: (See Bylaws for the AARST Consortium on National Radon Standards available at www.radonstandards.us.) Section 2.1 of Operating Procedures for Appeals (Appendix B) states, “Persons or representatives who have materially affected interests and who have been or will be adversely affected by any substantive or procedural action or inaction by the AARST Consortium on National Radon Standards committee(s), committee participant(s), or AARST have the right to appeal (3.1). Appeals shall first be directed to the committee responsible for the action or inaction.”

Metric Conversions
Conversions from English-American measurement units to the International System of Units (SI) are rendered herein with literal conversion. The conversions are not always provided in informational text or tables. It is acknowledged that rounding off to a similar numeric conversion is common (i.e., 4.0 pCi/L rounded to 150 Bq/m³ rather than literal conversion to 148 Bq/m³) for locations where the International System of Units (SI) are used.

Normative Reference:

Other Referenced Standards:
• ANSI/AARST MAH “Protocols for Conducting Measurements of Radon and Radon Decay Products in Homes”
• ANSI/AARST MALB “Protocols for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings”
• ANSI/AARST RMS-MF “Radon Mitigation Standards for Multifamily Buildings”
See: www.ansi.org or www.aarst-nrpp.com/wp/store/

Keywords
Radon Gas, Radon Test, Multifamily, Radon Measurement, Radon Testing, Radon, Multifamily Housing

MAMF History
At the request of Congress, EPA developed the document “Radon Measurement in HUD Multifamily Buildings” to enable HUD to comply with the requirements of the Stewart McKinney Amendments to the 1988 Indoor Radon Abatement Act. In 2004, the American Association of Radon Scientists and Technologists published the “AARST Interim Protocols for Conducting Radon Measurements in Multifamily Buildings” that built on EPA’s work and added consortium review and revision.

ANSI/AARST MAMF 2012 was published after more extensive due process and public review required for American National Standards and ANSI accreditation.

Summary of MAMF Updates for 2017
The significant review and amendments contained in this document are the result of scheduled review for AARST MAMF 2012 and include:

1) Procedural clarity when conducting measurements.
   The committee deliberated for more than a year with recurring focus on procedural clarity. Experiences during the last 5 years revealed text provisions intended to be informative that were witnessed to cause confusion. Each provision was reviewed and truncated or expanded as appropriate to provide clarity on intended requirements.

2) Consistency with newer AARST measurement protocols.
   Recent work by other radon measurement committees was reviewed for MAMF committee discussions on specific topics (e.g., ANSI/AARST MAH 2014 and ANSI/AARST MALB). Amended revisions resulted in:
   a) Clarification on individuals considered qualified to design and conduct test programs;
   b) Summary reports and report language requirements;
   c) Expanded detail on building components as related to closed-building requirements; and
   d) Reconciliation for the use of radon decay monitors.

3) New options when complex HVAC systems are present.

4) Clarity on procedures when all locations stipulated in MAMF (e.g., all ground-contact dwellings) were not tested in previous testing.

Note
The following “Introduction to Radon” are two pages intended to be copied and distributed as applicable to building occupants, property managers or other individuals who may benefit from this knowledge.
Introduction to Radon

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

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

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

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

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

C. Radon Exposure
Because many people spend much of their time at home, the home is likely to be the most significant source of radon exposure. According to EPA, nearly 1 out of every 15 homes in the United States is estimated to have radon concentrations that exceed the EPA action level.

Elevated concentrations of radon have been found in homes and buildings in every state. While elevated radon may be more common in some areas, any building can have a problem. EPA recommends that ALL buildings should be tested regardless of the area of the country and that maps should not be used to determine whether to test. More specific information on the likelihood of elevated radon in your area can frequently be found at your state or county radon offices.

The concentration of radon in the air within a building should be reduced below EPA’s radon action level of 4 pCi/L. Any radon exposure creates some risk; no concentration of radon is safe. Even radon concentrations below 4 pCi/L pose some risk, and the risk of lung cancer can be reduced by lowering indoor radon concentrations. This action level is based largely on the ability of current mitigation technologies to consistently reduce radon concentrations below 4 pCi/L. Depending on the building characteristics, radon concentrations in some buildings can be reduced well below 4 pCi/L. In others, reducing radon concentrations to below 4 pCi/L may be more difficult.

D. Radon Entry into Buildings
Radon in soil gas is the main source of radon problems. Pathways for radon to enter a building include cracks in the slabs and walls, the expansion joints between floor and walls, porous concrete block walls, open sump pits, crawlspaces and openings around utility penetrations. Some buildings have other pathways for radon to enter a building such as sub-slab utility tunnels and heating, ventilating and air conditioning (HVAC) ducts.
Radon gas can also enter buildings in well water. Though less commonly a concern, radon from well water used in a building can off-gas and raise the concentrations. For dwellings or small communities serviced by well water, a test of the water for radon should be considered. For more information on testing radon in drinking water, contact your state radon office.

Sometimes building materials that contain uranium and radium can produce radon. A radiation professional or your state radiation program can help you evaluate this possibility.

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

- The concentration of radon in the soil gas (source strength);
- The permeability of the soil or sub-surface geology (gas mobility) under the building;
- The structure and construction of a building; and,
- The type, design, operation, and maintenance of the heating, ventilating and air-conditioning (HVAC) system.

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

Gas mobility: Certain geological features beneath a building, such as cracks, fissures, or solution cavities, can serve as a direct connection between the radon-producing minerals and the building’s foundation. Such a direct connection can cause one unit of a building to have a radon concentration significantly higher than other units in the area. The permeability of the soil under a building, along with the differences between the air pressure inside a building and the air pressure under a building’s foundation influence the rate at which radon enters a building. For example, if the air pressure in the building is greater than the air pressure under the building’s foundation, radon should not enter through the openings of a building’s foundation. If the air pressure in the building is less than the air pressure under the building’s foundation, radon in the soil gas will enter through any openings in the building’s foundation.

Structure and construction: Any building design can have a radon problem. Without testing, you cannot know if elevated concentrations of radon are present.

Heating, cooling and ventilation systems (HVAC): Depending on their design and operation, HVAC systems can influence radon concentrations in buildings:

- Fresh air ventilation serves to dilute indoor radon concentrations with outdoor air; however radon’s source strength commonly overwhelms the practical limits of increasing ventilation to reduce occupant exposure.
- Poor ventilation provides less dilution to indoor radon concentrations.
- Depressurized buildings draw radon inside.
- Pressurizing a building helps keep radon out.

The frequency and thoroughness of HVAC maintenance can sometimes play an important role. For example, air intake filters that are not periodically cleaned and changed can significantly reduce the amount of outdoor air ventilating the indoor air environment. An understanding of the design, operation, and maintenance of a building’s HVAC system and how it influences indoor air conditions is helpful for understanding and managing a radon problem, as well as many other indoor air quality concerns in buildings. However, since HVAC systems are only one of many factors that affect radon concentrations in a building, HVAC system modifications alone are often not an effective radon mitigation strategy.

E. Contacts for Additional Information

- EPA website: [www.epa.gov/radon](http://www.epa.gov/radon)
- Indian Nation radon offices: [www.epa.gov/epahome/tribal.htm](http://www.epa.gov/epahome/tribal.htm)
- Regional EPA offices: [www.epa.gov/epahome/locate2.htm](http://www.epa.gov/epahome/locate2.htm)
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: [www.nrsb.org](http://www.nrsb.org)
- The AARST National Radon Proficiency Program (AARST-NRPP): [aarst-nrpp.com](http://aarst-nrpp.com)
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**MAMF Committee Members 2015-2016**

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Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily Buildings
1.0 PURPOSE AND SCOPE

1.1 Purpose
The purpose of conducting radon measurements is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary in order to protect current or future occupants. The purpose of test protocols is to produce reliable and repeatable radon measurements.

1.2 Scope
These protocols address radon measurements:

a) in buildings having more than one attached dwelling or other occupied unit under the same ownership or designated maintenance or management authority.

b) in buildings or structures, or a portion thereof that are used, for example, as apartment houses, dormitories, military congregate residences, fraternities and sororities, nontransient boarding houses, hotels, convents, monasteries, motels, and live/work units.

c) in 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.

1.2.1 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
The term “shall” and phrases that stipulate a prescribed action are provisions herein that are considered mandatory. Terms such as “should”, “recommended” or “informative” indicate provisions considered good practice or informational, but which are not mandatory.

2.0 PREPARING FOR THE MEASUREMENT

2.1 Devices and Personnel

2.1.1 Approved testing devices
All devices used for measuring radon and radon decay products shall be listed as having met minimum requirements established by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB) if the jurisdiction has no program for evaluating or approving devices where the testing is conducted.

2.1.2 Device instructions
Detectors and devices shall be used in compliance with device-specific 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.

2.1.3 Device types
For the purpose of this document:

a) Passive Devices refers to those that do not provide hourly readings; and

b) Continuous Monitors are monitors that can integrate, record and produce reviewable readings in time increments of 1 hour. 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.

2.1.4 Quality Control (QC) prior to testing
Informative advisory—For large testing projects, additional QC procedures should begin prior to deployment. (See Section 5.5.)
2.1.5 “Qualified Measurement Professionals” (multifamily) 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:

“An individual who has demonstrated a minimum degree of appropriate technical knowledge and skills sufficient both to place, retrieve and analyze (as applicable) radon detectors and to design, plan, and implement quality procedures when conducting radon measurements in multifamily buildings:

a) as established in certification requirements of the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); and
b) as required by statute, state licensure or certification program, where applicable.”

2.1.5.1 A “Qualified Measurement Professional” shall be physically present onsite during 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 or retrieving detectors.

2.1.5.2 Individuals who are not “Qualified Measurement Professionals” are permitted to assist in placement and retrieval of detectors provided their participation is permitted by statute, state licensure or certification program and approved by the Qualified Measurement Professional. Participant names and qualifications or preparations shall be retained in QC records and made available to the client upon request. If noncertified individuals are to conduct placement and retrieval of detectors, the Qualified Measurement Professional shall either:

a) Create and present a written work plan specific to apportioned tasks and verify that it is understood by all participants (see Companion Guidance figures CG 6.3 and CG 6.4); or
b) Verify that individuals have demonstrated, within the last 2 years, appropriate training and skills specific to detector placement and retrieval in multifamily buildings such as completion of a training class approved by the NRPP or NRSB and state licensure or certification program, where applicable.

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

Informative Advisory—It is recommended to confirm:

a) who is authorized by the client to receive test data and also, any limits the client requests or requires on disclosing test data or results; and
b) at which junctures during the testing process the client requests or requires data to be provided. This is especially important when the results are inherently not conclusive until follow-up or other additional measurements are complete. (See Section 4.6.2.)

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.

2.3 Assemble Building Information Prior to Testing

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.

2.3.3 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.

2.4 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:

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

3.0 WHERE TO TEST (Protocol Requirements)

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.

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.

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:

- are occupiable with little or no modification; or
- 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

Informative note—When in doubt, it is recommended to test the area. These unoccupied areas may serve as a pathway for radon into apartments and offices of upper floors.

3.3 Large Rooms or Open Areas

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

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

Informative advisory—Whenever additional test locations are warranted, preferred rooms are bedrooms, general living areas and any other major area that can be closed off from the main part of the dwelling. When in doubt, it is recommended to test the area.

3.6 Choosing a Test Location in a Room

<table>
<thead>
<tr>
<th>Place detectors within the general breathing zone and locate detectors no less than:</th>
<th>3 feet (90 cm) from exterior doors and windows or other potential openings to the outdoors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 inches (50 cm) above the floor.</td>
<td></td>
</tr>
<tr>
<td>1 foot (30 cm) from the exterior wall of the building.</td>
<td></td>
</tr>
<tr>
<td>4 inches (10 cm) from other test detectors and objects that are above or to the side of the detector. Exception: Less than 4 inches (10 cm) is permitted for detectors that are not affected by close proximity to other objects. Confirm manufacturer or laboratory requirements or recommendations prior to exercising this exception.</td>
<td></td>
</tr>
<tr>
<td>1 foot (30 cm) below the ceiling, with a preferred height being less than 8 feet (2.5 m) above the floor.</td>
<td></td>
</tr>
</tbody>
</table>

| Place detectors where they are 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. |

| Place detectors where they are not influenced by other factors: |
| Do not place detectors inside closets, crawlspaces and mechanical/furnace closets. |
| Do not place detectors within enclosed areas of high humidity. Examples include bathrooms, laundry rooms and kitchens isolated by partitions or other enclosures. Exception: Such locations should be avoided but are permitted for detector types that are virtually unaffected by high humidity. Confirm manufacturer or laboratory requirements or recommendations prior to exercising this exception. |
| Do not place detectors inside cupboards, sumps or nooks within the building foundation. |
| Do not place detectors near drafts caused by heating and air conditioning vents or fans. |
| Do not place detectors near heat sources, such as on appliances, radiators, near fireplaces or in direct sunlight. |
| Informative note—Avoid placing detectors on or near objects that may produce radiation such as natural stone (e.g. rock collections, granite counter tops, hearths or slate pool tables). |
4.0 TESTING PROCEDURES AND OPTIONS

Acceptable Testing Strategies

A. The Extended testing protocol (corresponding to EPA’s “Citizen’s Guide to Radon”) entails a quick and cost-effective initial test with follow-up testing in locations where elevated radon concentrations were initially measured. The Extended testing protocol is an option when time constraints are not prohibitive and when occupant relations allow the performance of a second test when needed.

B. Time-Sensitive testing protocols (corresponding to EPA’s “Home Buyer’s and Seller’s Guide to Radon”) require additional controls to aid reliability of results during a single phase of testing. Time-Sensitive testing protocols may be appropriate for situations where quick decisions are needed or when other strategies are unacceptable. Time-Sensitive situations may include: real estate transactions, planned renovations, or other situations that require a quick evaluation of whether radon mitigation is needed.

C. Additional Protocols for complex HVAC systems address challenging situations that can occur as a result of Multi-zone systems, Variable Air Distribution and Variable Outdoor Air Ventilation systems. (See Exhibit 1, for descriptions of these HVAC systems.)

D. Post-mitigation testing protocols address procedures for verification of mitigation system(s) effectiveness.

4.2 Extended Testing Protocol

<table>
<thead>
<tr>
<th>Table 4.2</th>
<th>Extended Testing Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Single Short-Term Test (Conduct an initial test with a single passive short-term detector at each location)</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Retest each location where the initial short-term tests meet or exceed the action level, e.g., 4 pCi/L.</td>
</tr>
<tr>
<td>* If the first short-term test is more than twice the action level (e.g., 8 pCi/L [296 Bq/m3] or greater), conduct a second short-term test immediately or as soon as possible.</td>
<td></td>
</tr>
<tr>
<td>* If the first short-term test is less than twice the action level (e.g., 4 to 8 pCi/L [148 to 296 Bq/m3]), conduct either a short-term or a long-term test.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Mitigation Decisions Base mitigation decisions on the results of testing in step 1 and step 2.</td>
</tr>
<tr>
<td>If the average of two short-term tests or the long-term test meets or exceed the action level, e.g., 4 pCi/L, Fix the building</td>
<td></td>
</tr>
<tr>
<td>If less than the action level, e.g., 4 pCi/L: Consider fixing the building if test results indicate radon concentrations greater than half the action level, (e.g., between 2 and 4 pCi/L). Any low test result should be confirmed by testing again during a different season or with a long-term test device. Be certain to test again whenever significant changes to the home’s structure or mechanical systems occur. Also, it is recommended to retest at least every 5 years.</td>
<td></td>
</tr>
</tbody>
</table>

4.1 Detector Deployment Periods

4.1.1 Test all areas during the same period (days or phase).

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.

Informative note—Whenever practical it is recommended, but not required, to terminate the test nominally at 24-hour increments to reflect day to night fluctuations in radon concentrations within a dwelling.

4.1.3 Long-term testing

For long-term tests, detectors shall be deployed for 91 days or more, and closed-building conditions are not required. Closed-building conditions should, however, represent a percentage of the test duration not less than the percentage of time across the year that buildings are kept closed due to the local climate. For a better understanding of the year-round average radon concentration, long-term tests should be conducted a minimum of 6 months over different seasons (one of which is a heating season) or as close to a year as possible to reflect seasonal changes in radon concentrations and building operation. (See the Companion Guidance Climate Maps-Average Conditions) for guidance.

4.1.4 Heating season testing

Tests conducted when outdoor temperatures are less than 65˚F (18˚C) for no less than half of the test duration.

4.1.5 Cooling season testing

Tests conducted when outdoor daytime temperatures exceed 83˚F (28˚C).
4.2.1 Step 1: Initial measurements (Extended Protocol)
Conduct initial measurements for two to 90 days under closed-building conditions in accordance with Section 6.

4.2.1.1 Quality Control (Extended Protocol)
The required number of duplicate measurements is no less than 10% of all testing locations. The required number of blank measurements is no less than 5% of all testing locations. (See Section 5.0 for additional QC requirements including spiked measurements.)

4.2.2 Step 2: Follow-up measurements (Extended Protocol)
Initiate follow-up measurements for all areas during the same time period (days or phase). Conduct a follow-up test, at a minimum, in every testing location with an initial short-term test result of 4 pCi/L (148 Bq/m³) or greater. Conduct QC in accordance with Section 4.2.1.1.

Informative notes—Detectors should be placed in the same locations as the initial measurements. Test additional locations as necessary, for example, invalid tests from the original testing series, other locations surrounding original elevated locations or locations or pathways that may influence elevated radon concentrations in the building.

4.2.2.1 Short-Term, Follow-up Testing
If the initial short-term measurement for a testing location is 8.0 pCi/L (296 Bq/m³) or greater (twice the EPA’s radon action level of 4 pCi/L [148 Bq/m³] or more) conduct a short-term follow-up test.

4.2.2.2 Long-Term, Follow-up Testing
When an initial test is less than twice the action level (e.g., 4.0 to 8.0 pCi/L [148 to 296 Bq/m³]), long-term follow-up testing can be considered instead of short-term testing.

4.2.3 Step 3: Mitigation decisions (Extended Protocol)
For Short-Term, Follow-up Testing: Use the average of the initial and follow-up test results to determine if this location needs mitigation.

For Long-Term, Follow-up Testing: Use the result of the long-term test to determine if this location needs mitigation.

4.2.3.1 When the Extended Protocol is used in Time-Sensitive situations: The results of Steps 1 and 2 are to be used for mitigation decisions.

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**Figure 4.2 Extended Testing Protocol**

---

** Conduct initial Short-Term measurement

If the result is < 4.0 pCi/L

If the result is ≥ 4.0 pCi/L but < 8.0 pCi/L

Conduct either:
- A Short-Term or Long-Term follow-up measurement

If the result is ≥ 8.0 pCi/L or results are needed quickly

A Short-Term follow-up measurement is conducted

Average the results of the initial and follow-up Short-Term measurements

Is the result ≥ 4.0 pCi/L ?

No

Yes

Is the result ≥ 2.0 pCi/L ?

No

Yes

Consider Fixing.

Remedial Action. Fix the building.

Test again at least every five years and whenever significant changes to the building’s structure or mechanical systems occur. Testing during a different season or with long-term tests is recommended.

** Choosing a time when closed-building conditions are a normal condition will aid in reliable measurements.**

* Long-term tests should be conducted as close to a year as possible
4.3 Time-Sensitive Testing Protocol

<table>
<thead>
<tr>
<th>Step 1 Options</th>
<th>Simultaneous Testing</th>
<th>Continuous Monitor Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Conduct two short-term tests at the same time at each location.)</td>
<td>(These monitors record hourly measurements.)</td>
</tr>
</tbody>
</table>

### 4.3.1 Step 1: Initial measurements (Time-Sensitive)

- **Simultaneous Testing Option**
  Conduct the measurement at each location with two short-term passive test detectors at the same time in the same location for two to 90 days under closed-building protocol conditions in accordance with Section 6.

  **QC:** The number of blank measurements required is no less than 5% of all testing locations. (See Section 5.0 for additional QC requirements including spiked measurements.)

- **Continuous Monitor Option**
  Conduct short-term tests for two to 90 days under closed-building protocol conditions in accordance with Section 6.

  **QC:** The required number of duplicate measurements for Continuous monitors is no less than 10% of all testing locations.

#### 4.3.1.2 Continuous Monitor Option

- Conduct short-term tests for two to 90 days under closed-building protocol conditions in accordance with Section 6.

#### 4.3.1.3 QC: Fixing when the action level is exceeded

- If the average of 2 short-term tests or a Continuous Monitor meets or exceed the action level, e.g., 4 pCi/L: **Fix the building**

- If less than the action level, e.g., 4 pCi/L: Consider fixing if test results indicate radon concentrations greater than half the action level, (e.g., between 2 and 4 pCi/L). Any low test result should be confirmed by testing again during a different season or with a long-term test device. Be certain to test again whenever significant changes to the home’s structure or mechanical systems occur. Also, it is recommended to retest at least every five years.

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**Figure 4.3 Time-Sensitive Testing Protocol**

[Diagram of the testing protocol showing the decision-making process]

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**Figure 4.3 Time-Sensitive Testing Protocol**

Conduct one of these Short-Term measurement options.

**Simultaneous Option:**
Place two Short-Term test devices adjacent to each other.

Average the results of the two measurements.

**Is the result ≥ 4.0 pCi/L?**

- **Yes:** Consider Fixing.
- **No:** Is the result ≥ 2.0 pCi/L?

- **Yes:** Remedial Action. Fix the building.
- **No:** Test again at least every five years and whenever significant changes to the building’s structure or mechanical systems occur. Testing during a different season or with long-term tests is recommended.
4.4 Additional Protocols for Complex HVAC Systems

<table>
<thead>
<tr>
<th>Step 1</th>
<th>4.4.1 <strong>Group 1 HVAC</strong>: Identify each unique area or dwellings not served by a dedicated (Group 1) basic heating and cooling system. (See Exhibit 1 for HVAC group descriptions.)</th>
</tr>
</thead>
</table>
| Step 2 | 4.4.2 **Group 2 HVAC: Multi-zone HVAC Systems**  
It is recommended to place enough additional detectors to adequately characterize and record differences between rooms that are served by different HVAC systems within the same dwelling or unique sector. |
|        | 4.4.3 **Group 3a HVAC: Variable Distribution Systems**  
It is recommended when Variable Distribution Systems are a component of the HVAC system that each bedroom, general living area and any other major area that can be closed off from the main part of the dwelling or unique sector be tested. |
|        | 4.4.4 **Group 3 HVAC: Variable Distribution and/or Variable Ventilation HVAC Systems**  
Requirements In addition to those in Section 6 (Conditions Required Before and During the Test):  
a) Thermostats shall be set to a normal occupied temperature of 65-80° F (18-27° C) in all ground-contact and upper floor rooms or unique sectors being tested that are served by the system; and  
b) Outside air inlet dampers that are adjusted for seasonal comfort or energy savings shall be set to minimum ventilation settings when systems are designed to provide a degree of outside air ventilation throughout the year. For other systems, dampers to outside air shall be closed. |
|        | 4.4.5 **Mitigation Decisions**: Base decisions on the results of testing as stipulated for the chosen test protocol (e.g., Extended, Time-Sensitive or Group 3 Alternative Options 1 or 2). |

4.4.6 **Group 3 HVAC—Alternate Option 1**  
Conduct tests in accordance with ANSI/AARST MALB.

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.

**Figure 4.4 Additional Protocols for Complex HVAC Systems** (See Exhibit 1 for HVAC group descriptions.)
4.5 Post-Mitigation Testing Protocols

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.

4.5.2 Systems operational (active radon reduction systems)
Prior to short-term test periods of not less than two days, active radon reduction system(s) shall have been operating for at least 24 hours and shall continue to operate during the test period. In addition, closed-building conditions shall be maintained 12 hours prior to short-term test periods and throughout the test.

4.5.3 Initial post-mitigation testing (active systems)
Conduct short-term testing for initial post-mitigation evaluations with no less than a single short-term detector or device at each test location. This procedure is also required for buildings constructed with radon resistant new construction when fans have been installed regardless if prior testing of the building has been conducted.

4.5.4 Subsequent post-mitigation testing
Conduct no less than a single short-term or long-term detector at each test location to evaluate continued effectiveness of the mitigation system.

4.5.5 QC
The required number of duplicate measurements is no less than 10% of all testing locations. The number of passive device blank measurements required is no less than 5% of all testing locations.

4.5.6 Diagnostic radon testing
Diagnostic testing is not sufficient to verify mitigation effectiveness.

4.6 Special Considerations

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.

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.

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 adjoining 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.

4.6.4 Regions with geologic considerations
Informative advisory—If a foundation is connected to a sub-surface cave or cavity system, which connects to radon-producing strata, unusual or sizable variations in indoor radon concentrations can occur. The most common examples are buildings found in limestone-rich areas where groundwater has eroded passages in the underlying rock (karst) or areas with faulting, which could allow radon to be transported in an unusual manner. In regions where these geologic characteristics exist, it can be especially important to confirm low results by repeating tests during different seasons and weather conditions, or with long-term testing.
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.

5.1 Duplicate (or Collocated) Test Results

Informative note—Some variation between the results of duplicate detectors is expected. However, if the variation is unusually large, it may indicate problems that could adversely affect the entire testing series.

5.2 Blanks and Duplicates

Blanks and duplicates shall be part of a radon measurement professional’s QA plan and shall be included in the final report in accordance with Section 7.3.1.

<table>
<thead>
<tr>
<th>Table 5.2</th>
<th>General Quality Control (QC) Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duplicate Measurements</strong> (side-by-side detectors)</td>
<td><strong>Blank Measurements</strong> (unexposed detectors)</td>
</tr>
<tr>
<td>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).</td>
<td>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.</td>
</tr>
</tbody>
</table>

5.3 Blanks

Radon measurement professionals should consider deploying 3% field blanks and 2% office blanks to evaluate background exposures throughout the sampling process. Office blanks remain in the office setting. Field blanks are taken to the site.

5.4 Special Considerations for Blank Detectors in Large Deployments

Informative note—As the number of units to be tested in a building complex increases, the need for specialized blank procedures becomes greater. With a larger number of testing locations and detectors, the investiture of time and money for the client and the radon measurement professional becomes great enough to warrant that an early detection procedure is included in the blank deployment protocol.

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.

Informative note—As the number of locations to be tested for the project increases, the need for specialized spike procedures becomes greater. With a larger number of testing locations and detectors, the investiture of time and money for the client and the radon measurement professional becomes great enough that an early detection procedure should be included in the spike protocol. At a minimum of 100 locations to be tested, testers should ensure that the results of three spiked detectors from the sampling program batch have been received and are satisfactory (+25% of the chamber’s reference value) prior to beginning the sample deployment.
6.0 CONDITIONS REQUIRED BEFORE AND DURING THE TEST

6.1 Closed-building Protocol

Table (6.0-A) provides information that would normally be provided to occupants. Additional specifications are provided in Tables 6.0-B and 6.0-C.

<table>
<thead>
<tr>
<th>Table 6.0-A</th>
<th>CLOSED-BUILDING PROTOCOL REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For tests lasting less than 4 days, initiate closed-building conditions 12 hours prior to the test. MAINTAIN CLOSED-BUILDING CONDITIONS THROUGHOUT THE TEST PERIOD.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REQUIRED CLOSED-BUILDING CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows</td>
</tr>
<tr>
<td>Exterior Doors (except for momentary use)</td>
</tr>
<tr>
<td>Heating and Cooling Systems</td>
</tr>
<tr>
<td>Window Air Conditioners and Unit Ventilators</td>
</tr>
<tr>
<td>Window fans, whole building ventilation fans or systems that temporarily bring air into or out of the building for seasonal energy savings or comfort.</td>
</tr>
<tr>
<td>Fireplaces, including those that burn solid, liquid or gas fuels, unless they are the primary/normal sources of heat for the building</td>
</tr>
<tr>
<td>Bathroom fans</td>
</tr>
<tr>
<td>Ventilation components set for use in all seasons</td>
</tr>
<tr>
<td>Systems that temporarily draw air from the building such as exhaust from laundries, shops or for control of fumes from community kitchens.</td>
</tr>
</tbody>
</table>

Keep closed on all levels of the building including areas not being tested.

Set to normal with occupied operating conditions as normal (e.g., temperatures between 65˚ and 80˚ F).

Operate in recirculation mode only with outside air dampers closed.

Do not operate

Operate normally

Avoid excessive operation
## Table 6.0-B
### ADDITIONAL SPECIFICATIONS
(CLOSED-BUILDING PROTOCOL REQUIREMENTS)

<table>
<thead>
<tr>
<th><strong>Windows and Doors</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Broken windows or doors</td>
<td>Seal closed</td>
</tr>
<tr>
<td>Interior partition doors</td>
<td>No special requirements</td>
</tr>
<tr>
<td>Doors leading into a garage or to exterior</td>
<td>Keep closed, except for momentary entry and exit</td>
</tr>
<tr>
<td>Garage doors</td>
<td>Operate normally</td>
</tr>
<tr>
<td>Stairwell and fire doors</td>
<td><em>(Should retain closed condition except where normal operation requires otherwise.)</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Small Appliances</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling fans and portable fans</td>
<td>Do not blow directly on the testing device</td>
</tr>
<tr>
<td>Window fans</td>
<td>Remove or seal shut. Do not operate</td>
</tr>
<tr>
<td>Humidifiers</td>
<td>Operate normally</td>
</tr>
<tr>
<td>Dehumidifiers</td>
<td>Operate normally</td>
</tr>
<tr>
<td>Central vacuum cleaner systems</td>
<td></td>
</tr>
<tr>
<td>Portable air cleaners</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Crawl Spaces</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive crawlspace vents</td>
<td>Operation of vent dampers should reasonably reflect average yearlong operation.</td>
</tr>
<tr>
<td>Crawlspace exhaust systems for humidity control</td>
<td>Operate normally</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Major Mechanical Systems</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive vents for combustion air makeup</td>
<td>Leave open</td>
</tr>
<tr>
<td>Combustion appliance fans</td>
<td></td>
</tr>
<tr>
<td>Air cleaners</td>
<td>Operate normally</td>
</tr>
<tr>
<td>Passive solar systems</td>
<td></td>
</tr>
<tr>
<td>Attic Ventilation Fans that control only attic air</td>
<td></td>
</tr>
<tr>
<td>Evaporative (swamp) cooling systems</td>
<td>Do not operate</td>
</tr>
<tr>
<td>Heat Recovery Ventilators (HRV)</td>
<td></td>
</tr>
<tr>
<td>Energy Recovery Ventilators (ERV)</td>
<td>Do not operate. <em>Exception: Operate as normal if the system is configured to operate every day of the year for introducing a specified amount of outdoor air into the building. For ERV, this often requires disabled dampers that can otherwise deactivate a system during cold or hot weather.</em></td>
</tr>
</tbody>
</table>

**NOTE:** *Indicates items that require notation in reports for condition observed*
### Table 6.0-C  NEW CONSTRUCTION, RENOVATIONS AND REPAIRS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>All openings to the exterior as a result of incomplete construction, structural defect or disrepair</td>
<td>Close or Seal at least 12 hours prior to initiating the test</td>
</tr>
<tr>
<td>All heating/cooling appliances (functioning and set to run at normal occupied temperatures)</td>
<td></td>
</tr>
<tr>
<td>All insulation</td>
<td></td>
</tr>
<tr>
<td>All exterior doors and hardware</td>
<td></td>
</tr>
<tr>
<td>All windows</td>
<td></td>
</tr>
<tr>
<td>All wall and ceiling coverings to be completed including interior drywall or paneling, excluding decorative painting and finishing of walls, floors or ceilings</td>
<td>Items shall be completed or installed at least 12 hours prior to initiating the test</td>
</tr>
<tr>
<td>All door and window seals shall be installed</td>
<td></td>
</tr>
<tr>
<td>All exterior siding, weatherproofing and caulking</td>
<td></td>
</tr>
<tr>
<td>All components of fire-rated assemblies to include doors, walls, ceilings and other components required to achieve fire-rated separation(s)</td>
<td></td>
</tr>
</tbody>
</table>

### 6.2 Test Condition Verification

The test should include methods to prevent or detect interference with testing conditions or the testing detector. The radon measurement professional or occupant should be able to verify or provide documentation asserting that testing conditions were not violated during the testing period.

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

a) Informing the person responsible for building operation and the required test conditions;

b) Obtaining or attempting to obtain a signed noninterference agreement (See Exhibits 8 and 9);

c) Posting a Radon Test in Progress notification form. (See examples in Section Exhibit 7);

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.

#### 6.2.1 Surveillance not required

The radon measurement professional is not responsible for inspecting for closed-building conditions 12 hours before the start of the test or between placement and retrieval of the detectors.

#### 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).

#### 6.2.3 If closed-building conditions cannot be maintained

Do not conduct short-term tests if closed building conditions in accordance with Section 6 cannot be reasonably maintained across the test period. Clients should be advised to reschedule the test at a time when required conditions can be maintained.

#### 6.2.3.1 Occupant health and safety

If complying with closed conditions would present health hazards to occupants:

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.

Examples of situations that could present health hazards to occupants include during hot weather for buildings that have no cooling systems or where cooling systems require
seasonal enhancement of outdoor air ventilation such as evaporative (swamp) cooling systems or window fans.

6.2.4 Severe weather
Informative advisory—Short-term tests lasting less than 4 days should not be conducted during unusually severe storms or periods of unusually high winds.

6.3 Informative—Aids for Detecting Failed Compliance or Interference

6.3.1 Placement indicators
A position for the detector can be chosen and noted so that, upon retrieval, any handling or covering of the detector can be detected.

6.3.2 Seals
Non-re-sealable caulks and/or tapes can be used to verify that detectors have not been altered or moved; in addition, they can be used to verify that windows or non-primary exterior doors have not been opened during the test. If broken, seals may help determine if testing conditions were altered or a detector was disturbed. For a seal to be effective:
   a) It must adhere readily to a multitude of surfaces yet be easily removed without marring the surface;
   b) It needs to be non-re-sealable or show evidence of disturbance;
   c) It must be unique enough to prevent easy duplication; and
   d) It should be visible enough to discourage tampering.

Most paper or plastic tapes and caulks have only some of these qualities. There are, however, a number of seals manufactured specifically for radon testing. It would be advisable to use one of these products and follow the manufacturer’s recommendations for installation. The best caulking to use as a seal is a removable weather-stripping caulking. This type of caulking adheres readily to most surfaces yet comes off easily without leaving a mark or being re-sealable.

6.3.3 Control Monitors: The inclusion of at least a few detectors that provide hourly data indicating fluctuations in radon can aid confidence that no unusual conditions affected the measurement results. Hourly data for fluctuations of environmental factors such as temperature, humidity and barometric pressure can also aid identification of unusual conditions.

7.0 DOCUMENTATION, PROTOCOLS AND GUIDANCE
Final report documentation shall include:

7.1 A Summary Report
The following information shall be provided in a prominent location on a summary report.

7.1.1 Site location
The address of the building(s) tested, including zip code.

7.1.2 Measurement company
The name and contact information for the organization providing services to conduct the test.

7.1.3 The Measurement Professional’s identification and certification of quality practices:
   a) name, address and phone number;
   b) relevant radon measurement certification and/or licensing number; and
   c) signature (manual, or electronic in conformance with the Electronic Signatures in Global and National Commerce [E-SIGN] Act).

7.1.4 Laboratory identification
The name, address and relevant certification and/or licensing number of the service or organization used to analyze detectors.

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.

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.

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.

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.
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.

<table>
<thead>
<tr>
<th>7.1.8.1 Elevated Radon (e.g., ≥ 4 pCi/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCLUDE THESE ADVISORIES IN THE SUMMARY REPORT</strong></td>
</tr>
<tr>
<td>a) Fix the building (when a test location indicates average concentrations that equal or exceed the action level, e.g., 4 pCi/L).</td>
</tr>
<tr>
<td>b) Know that mitigation is not complete until retests provide evidence for the initial status of system effectiveness.</td>
</tr>
<tr>
<td>c) 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).</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Include this advisory in summary reports when testing indicates a radon source other than soil gas.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td><strong>PROTOCOL REQUIREMENT—ADVISORY REQUIRED</strong></td>
</tr>
<tr>
<td>Include an advisory of the following requirement in summary reports that applies when initial testing strategy did not include all ground-contact dwellings and/or upper floors as prescribed in Section 3.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

Informative example — Appropriate equivalent message

“The radon measurement indicates that occupants may be exposed to radon concentrations that equal or exceed the EPA action level of 4.0 pCi/L. It is recommended to fix the building.”

<table>
<thead>
<tr>
<th>7.1.8.2 Initial Post-Mitigation Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROTOCOL REQUIREMENT—ADVISORY REQUIRED</strong></td>
</tr>
<tr>
<td>Include an advisory of the following requirement in test proposals and summary reports that recommend mitigation of ground-contact areas.</td>
</tr>
<tr>
<td>a) <strong>Test locations after mitigation:</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td><strong>ADVISORY REQUIRED</strong></td>
</tr>
<tr>
<td>Include this advisory in test proposals and summary reports that post-mitigation testing was not conducted during the heating season.</td>
</tr>
<tr>
<td>c) <strong>Seasonal verification:</strong></td>
</tr>
<tr>
<td>It is recommended to repeat testing of mitigated buildings under heating season conditions no later than within the first year after mitigation.</td>
</tr>
<tr>
<td><strong>PROTOCOL REQUIREMENT—ADVISORY REQUIRED</strong></td>
</tr>
<tr>
<td>Include an advisory of the following requirement in test proposals and summary reports that applies when mitigation systems rely on passive methods or active pressurization or dilution of indoor building air.</td>
</tr>
<tr>
<td>d) <strong>Passive, pressurization or dilution mitigation methods:</strong></td>
</tr>
<tr>
<td>• 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.</td>
</tr>
<tr>
<td>• In addition, conduct testing in all dwellings on the floor where elevated concentrations were found and in all vertically adjoining dwellings.</td>
</tr>
</tbody>
</table>
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.

The narrative can also recommend retesting individual locations versus the building if neither of the above conditions (a or b) were met.

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.

7.1.8.3 Subsequent Post-Mitigation Retests

**ADVISORIES REQUIRED**

Include these advisories in summary reports to include reports that recommend mitigation, post-mitigation reports, and whenever mitigation systems are found to be present in a building.

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.

Include advisories on seasonal testing as applicable (Sections 7.1.8.2 c and d, and Sections 7.1.8.4 b and e.)

Include advisories on other situations that warrant retesting identified in Sections 7.1.8.4 a, d and e.

7.1.8.4 Low Concentrations (e.g., < 4 pCi/L)

**ADVISORIES REQUIRED**

Include this advisory in the summary report for low test results that are greater than half the action level.

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

Include this advisory in summary reports that report low test results but testing has not been conducted in the heating season.

b) It is recommended to repeat testing of all buildings under heating season conditions at the earliest opportunity and no later than within 5 years after initial testing.

c) It is recommended to alternate the season for future testing events to obtain at least one test under a different season that represents a significant portion of the yearlong operating condition for the building (e.g., cooling season conditions).

d) Retest all building(s) at least every 5 years and in conjunction with any sale of a building.

e) In addition, be certain to test again 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;
- Heating or cooling systems are altered with changes to air distribution or pressure relationships;
- Ventilation is altered by extensive weatherization, changes to mechanical systems or comparable procedures;
- Sizable openings to soil occur due to: - ground water or slab surface water control systems are added or altered (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.); or - natural settlement causing major cracks to develop;
- Earthquakes, construction blasting or formation of sink holes nearby; or
- A mitigation system is altered, modified or repaired.
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. It is permitted that a statement be included in the report that the test company offers no findings as to the proper operation of the system.

7.1.11 Statement of test limitations
The summary report should also describe the general limitations of the test.

An example is the following statement: “There is an uncertainty with any measurement result due to statistical variations and other factors such as daily and seasonal variations in radon concentrations. Variations may be due to changes in the weather, operation of the dwelling or possible interference with the necessary test conditions.”

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.

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).

7.3.2 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.

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.

7.3.4 Protocol for testing
Identify the test protocol employed for conducting the test (e.g., “ANSI/AARST MAMF 2017”).

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.

7.4 Report Detector and Test Location Information

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.

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.

7.5 Report Noninterference Controls
a) Include a description of any noninterference controls used such as tamper seals, control monitors that may include continuous radon monitors or other methods.

b) Include information on whether responsible individuals signed declarations of observed compliance (see Exhibits 8 and 9).

7.6 Report Protocol Deviations
Include a description of any observed deviations from appropriate measurement procedures that may affect the measurement results including:
   a) observed noncompliance with or deviations from required conditions such as closed-building conditions, prior to or during the test period;
   b) observed deviations from a normal indoor occupied temperature;
   c) changes in the detector’s placement or indications from other noninterference controls that might indicate interference with the test; and
   d) any observed anomalies in data printed from a continuous radon monitor that may indicate interference with the detector or test conditions or noncompliant testing 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
shall have demonstrated a minimum degree of appropriate technical knowledge and skills specific to RDP measurement:

Individuals placing, retrieving and analyzing RDP detectors training in order to properly account for a wide variety of site-specific conditions and technology considerations. See Companion Guidance CG Section 5 for more information. Individuals placing, retrieving and analyzing RDP detectors shall have demonstrated a minimum degree of appropriate technical knowledge and skills specific to RDP measurement:

a) as established in certification requirements by the NRPP or the NRSB; and/or
b) as required by statute, state licensure or certification program, where applicable.

8.2 Units of Measurement and Action Level
When radon decay products are measured, the unit of measurement provided by devices is in Working Level (WL). Historically the action level has been cited as 0.02 WL.

8.3 Gas Measurement Also Required
RDP measurement devices shall not be used unless accompanied with a simultaneous radon gas measurement when the test is for determining the need for mitigation. This allows evaluation of ventilation conditions that can affect the solid decay product concentrations as compared to gas concentrations.

8.4 Reporting Requirements When Using RDP Monitors
8.4.1 Conventions: Radon decay product results reported in Working Level (WL) shall be reported to no more than three figures after the decimal (e.g. 0.012 WL).

8.4.2 Conversions
Conversions shall not be made between measurements of radon gas (pCi/L or Bq/m³) and measurements of radon decay products (WL) for the purpose of determining if mitigation is needed.

8.4.3 Recommended actions
Both radon gas and RDP measurements shall be reported along with references to their respective action levels and recommended actions (in accordance with Section 7.1.7) that apply collectively or individually to each measurement.

8.4.4 Report observed conditions
In addition to all other requirements in Section 7.0, the report shall include a listing of all items from Table 8.0 and the condition of each during the test.

8.4.5 Special situation
If one collocated measurement (either radon gas or RDP) meets or exceeds the action level, and the other does not:

8.4.5.1 Further interpretation is not required in the report.

8.4.5.2 Interpretations
When an interpretation is requested or reported regarding such discrepancy and decisions to mitigate, reports shall include an assessment of items observed from Table 8.0 or as determined by more thorough investigation. The assessment shall evaluate characteristics of the building that can affect RDP concentrations and, at a minimum, identify both:

a) characteristics of the specific building as they might be expected to either increase or decrease suspended radon decay products concentrations; and
b) the degree to which such characteristics are either temporary in duration or reasonably stable conditions for that building.
### Table 8.0  RDP MEASUREMENT

#### ADDITIONAL CLOSED-BUILDING PROTOCOL AND REPORTING REQUIREMENTS

**For Local Airspace**

“Local Airspace” is defined as:
The room and any adjoining rooms that are not physically isolated by partitions and closed doors.

<table>
<thead>
<tr>
<th>Item</th>
<th>Action</th>
<th>Reporting Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Ceiling Fans</td>
<td>Disallow use</td>
<td>✓ List each item on the report</td>
</tr>
<tr>
<td>☐ Circulating Fans</td>
<td>Choose a different test location</td>
<td>✓ Report existence of any items present and any deviations in required action</td>
</tr>
<tr>
<td>☐ Filtration and Electrostatic Air Cleaners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Unvented Fireplaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Vacuum Cleaners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Humidifiers or Dehumidifiers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Particulate Creation such as:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ - smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ - cooking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ - burning candles/other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ - pets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Proximity to electrostatic fields such as</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ - tube TV or computer screens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ HVAC Blower Activity</td>
<td>Evaluate</td>
<td>✓ Report deviations from expected normal use</td>
</tr>
<tr>
<td>☐ Occupied or Unoccupied</td>
<td>Evaluate</td>
<td>Report condition</td>
</tr>
<tr>
<td>☐ HVAC Filtration and Electrostatic Air Cleaners</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ HVAC Combustion Byproducts</td>
<td>Evaluate</td>
<td>✓ Document all systems present.</td>
</tr>
<tr>
<td>☐ HVAC Duct Cleanliness</td>
<td>Evaluate</td>
<td>✓ Report their conditions</td>
</tr>
<tr>
<td>☐ Split Systems</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Humidifiers or Dehumidifiers</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Atypical Outdoor Air Pollution</td>
<td>Evaluate</td>
<td>✓ Report condition</td>
</tr>
<tr>
<td>☐ Humidity</td>
<td>Evaluate</td>
<td>✓ Report deviations from normal yearly average</td>
</tr>
</tbody>
</table>

**For Whole Building or Zone**

“Whole Building or Zone” is defined as:
The entire building or local zone that is served by an air handler.

<table>
<thead>
<tr>
<th>Item</th>
<th>Action</th>
<th>Reporting Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ HVAC Blower Activity</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Occupied or Unoccupied</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ HVAC Filtration and Electrostatic Air Cleaners</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ HVAC Combustion Byproducts</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ HVAC Duct Cleanliness</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Split Systems</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Humidifiers or Dehumidifiers</td>
<td>Evaluate</td>
<td></td>
</tr>
</tbody>
</table>

**Outside the Building**

<table>
<thead>
<tr>
<th>Item</th>
<th>Action</th>
<th>Reporting Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Atypical Outdoor Air Pollution</td>
<td>Evaluate</td>
<td></td>
</tr>
<tr>
<td>☐ Humidity</td>
<td>Evaluate</td>
<td></td>
</tr>
</tbody>
</table>
9.0 DEFINITION OF TERMS

Basic Heating and Cooling: See Exhibit 1, Group 1. A dedicated HAC system for each room or unique area that does not supply additional fresh air for ventilation.

Becquerel per cubic meter (Bq/m³): A unit of radioactivity representing one disintegration per second per cubic meter: 1 Bq/m³ (0.027 pCi/l).

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

Client: The individual or parties who hire(s) and/or pay(s) for the radon test.

Collocated: Two or more simultaneous measurements in the same location, or side-by-side.

Complex HVAC: See Exhibit 1.

Continuous Radon Monitor (CR or CRM): Test devices that are capable of, and set to, record and review radon in time increments of one hour or less.

Crawlspace: 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 crawlspace can have an open height of a few inches to several feet. The crawlspace can be storage space but is not living space, and may or may not be ventilated to the outside.

Duplicate Measurements: Duplicates are pairs of detectors or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between detectors. See Appendix A and Section III for more information.

Equilibrating Detector: A detector that functions by adsorbing and/or desorbing radon from or to the ambient air until an equilibrium condition is reached between the radon concentration in the detector and the radon concentration in the ambient air. Equilibrating detectors include 1) activated charcoal in containers, such as canisters, bags or trays, which are analyzed in a laboratory using gamma-ray spectroscopy and 2) activated charcoal in containers, such as cartridges or vials, which are analyzed in a laboratory using liquid scintillation spectroscopy.

Exposure Time: The length of time a detector must sample radon to get an accurate measurement. Also called “exposure period,” or “duration of exposure.”

Extended Testing: An initial short-term test is followed by a short- or long-term test if a radon concentration is found to be elevated. The decision to mitigate is based on the average of two short-term tests or the result of the long-term test.

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. If they also provide fresh air ventilation, they are more technically referred to as HVAC systems.

HVAC System: Heating and cooling (air conditioning) systems that are additionally capable of supplying fresh air ventilation. If they do not supply fresh air ventilation, they are more technically referred to as HAC systems.

Integrating Device: A device that records, or registers in some manner, information that is directly related to the integral of ambient radon concentration over time within the operating range of the device. Integrating devices include 1) electret ion chambers which are analyzed after the fact by measuring a decrease in electrical potential on the electret, 2) alpha-track detectors which are analyzed after the fact by etching and measuring the track density in a plastic matrix and 3) electronic devices that are not set to, or are incapable of, recording radon concentration in time increments of one hour or less.

Measurement Professional: (See Radon Measurement Professional)

Mitigation System: Any system designed to reduce radon concentrations in the indoor air of a building.

Multifamily Building: A building with more than three attached dwellings.
Multi-Zone Systems: See Exhibit 1, Group 2. Independent systems and controls for different areas within the same room or unique sector.

Picocurie (pCi): One pCi is one trillionth of a curie (10^{-12}) or 0.037 disintegrations per second or 2.22 disintegrations per minute.

Picocurie per liter (pCi/L): A unit of concentration of radioactivity corresponding to 0.037 decays per second or 2.22 decays per minute in a liter of air or water. 1 pCi/L = 37 becquerels per cubic meter (Bq/m³).

Quality Assurance (QA): A complete program designed to produce results that are valid, scientifically defensible, and of known precision, bias and accuracy. Includes planning, documentation, and quality control (QC) activities.

Quality Control (QC): The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. Includes calibrations and backgrounds, duplicate, blank, and spiked measurements, inter-laboratory comparisons, audits and other control activities.

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.

Radon Measurement Professional: Any state licensed or nationally certified person or entity that conducts radon testing for remuneration. A professional holds a current radon license from a state where radon testing services are regulated or current national certification recognized by the state in which the test is being conducted. Or, if the testing is being conducted in a non-regulated state, then the professional should have current certification recognized by the non-regulated state.

Relative Percent Difference (calculations): The relative percent difference between a pair of duplicate measurement detectors is calculated by dividing the difference between the two results by the average of the two results and multiplying by 100.

$$ RPD = \left( \frac{|X_1 - X_2|}{X_{ave}} \right) \times 100\% $$

where:

- $X_1$ = result of detector 1
- $X_2$ = result of detector 2
- $|X_1 - X_2|$ = absolute value of the difference between detectors 1 and 2
- $X_{ave}$ = average concentration = $\frac{(X_1 + X_2)}{2}$

Example:
- $X_1 = 9.0$ and $X_2 = 8.0$
- $RPD = \left( \frac{|9 - 8|}{8.5} \right) \times 100\% = 1/8.5 \times 100\% = 11.8%$

Relative Percent Error (calculations): The relative percent error (RPE) is the difference between the known or reference concentration of radon used by a chamber to spike a detector and the resulting measurement value after analysis of the spiked sample, expressed as a percentage of the known concentration. The RPE may be either a positive or negative number, indicating whether the measured concentration is higher or lower than the known concentration. RPE is calculated by subtracting the known concentration from the measured concentration, dividing by the known concentration, and multiplying the result by 100%.

$$ RPE = \frac{(MV - TV)}{TV} \times 100\% $$

where:

- $MV$ = measured value of detector
- $TV$ = target value of radon chamber

Example:
- $MV = 11.0$ and $TV = 10.0$
- $RPE = \frac{(11-10)}{10} \times 100\% = 10\%$

Single Family Dwelling: A residence or home intended to house a single family and requiring discrete testing location(s).

Spiked Measurements: Spikes are detectors that have been exposed in an approved chamber to a known concentration of radon (i.e. “spiked” with radon). Using spiked measurements can help evaluate the accuracy of a laboratory analysis and/or how accurately detectors supplied by a laboratory measure radon. See Appendix A and Section III for more information.
Standard Operating Procedure: A written document that details an operation, analysis, or action whose mechanisms are prescribed thoroughly and which is commonly accepted as the practice to be followed for conducting certain routine or repetitive tasks.

Test Interference: The altering of test conditions prior to or during the measurement in order to change the radon or radon decay product concentrations, or the altering of the performance of the measurement equipment.

Time-Sensitive: A measurement strategy that involves a single phase of testing, requiring enhanced quality control measures. Time-sensitive tests include Simultaneous, and Continuous Monitor testing.

Variable Air Distribution: See Exhibit 1, Group 3-b. Systems where airflow from a single air handler is distributed among multiple dwellings with independent thermostat controls in each dwelling that variably open and close dampers for heated or cooled supply air.

Variable Outdoor Air Ventilation: See Exhibit 1, Group 3-b. Systems that seasonally vary outdoor air ventilation for: individual dwellings; multiple dwellings; or the whole building.

Working Level (WL): A unit of radon decay product concentration. One WL equals any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3 x 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.

MAMF Consensus Body Members 2015-2016

Acknowledgement

Deep appreciation is both expressed and deserved for contributions in time and wisdom provided by all previous committee members and the 2015-2016 committee members that represent a cross-section of stakeholder interests and vantage points.

Chair: Shawn Price (NC)

Assistant Team: Gary Hodgden (KS)

Stakeholder Group | Delegate | Affiliation
--- | --- | ---
(Educators) | Doug Kladder (CO) | Center for Env. Research & Technology (CERTI),
(Non-regulated States) | Chrys Kelley (CO) | Colorado Department of Health and Environment
(Regulated States) | Patrick Daniels (IL) | Illinois Emergency Management Agency (IEMA)
(Health NGO) | Kevin Stewart (PA) | American Lung Association
(Federal EPA) | Jani Palmer (DC) | U.S. Environmental Protection Agency (EPA)
(Federal HUD) | Sara Jensen (DC) | HUD Office of Housing
(Federal HUD) | Hilary Atkin (DC) | HUD Office of Housing
(Proficiency Program) | Kyle Hoyalman (KY) | AARST-NRPP (Credentialing Committee)
(Proficiency Program) | Bill Angell (MN) | AARST-NRPP (Credentialing Consultant)
(Mitigation Prof.) | Tim Pittman (SC) | Professional Service Provider
(Measurement Prof.) | Wally Dorsey (VA) | Professional Service Provider
(Measurement Prof.) | Jessica Karns (OH) | Professional Service Provider
(Building Inspectors) | Matt Koch (GA) | Professional Service Provider
(Building Scientist) | Mort Schmidt (OH) | Professional Service Provider
(Environmental Consultant) | Kim Dingleidene (VA) | Professional Service Provider
(Environmental Consultant) | Mike Walther (MD) | Professional Service Provider
(Manufacturer) | Alex Stieff (MD) | Rad Elec, Inc.
(Manufacturer) | Rick Straub (OH) | femto-TECH, Inc.

Standards Assistance Team: Erin Brown, Nanci Hemberger, Stephany De Scisciolo and Joanna Mandecki
EXHIBITS

EXHIBIT 1

Page 1: HVAC GROUP DEFINITIONS

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

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

<table>
<thead>
<tr>
<th>HVAC - DEFINITIONS AND SPECIAL CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1: Basic Heating and Cooling</strong></td>
</tr>
<tr>
<td>A dedicated system for each dwelling or unique area that does not provide seasonally variable outdoor air ventilation for added comfort or energy savings.</td>
</tr>
<tr>
<td>• <strong>Forced-air</strong> heating and air conditioning (HAC) systems (such as normally seen in single-family residences).</td>
</tr>
<tr>
<td>• <strong>Ductless Systems</strong></td>
</tr>
<tr>
<td>- Non-Forced-Air Hot and Cold Water Circulation (sometimes called radiator systems).</td>
</tr>
<tr>
<td>- Window AC (w/fresh air closed).</td>
</tr>
<tr>
<td>- Unit Ventilators (w/fresh air closed).</td>
</tr>
<tr>
<td>- Wall or Baseboard heating/cooling.</td>
</tr>
<tr>
<td>• <strong>Ductless Split Systems:</strong> One system for cooling and one for heat (e.g., Window AC for cooling and Baseboard heat).</td>
</tr>
<tr>
<td>No Special Consideration</td>
</tr>
<tr>
<td><strong>Group 2: Multi-zone Systems</strong></td>
</tr>
<tr>
<td>Independent systems and controls for different areas within the same dwelling or unique sector.</td>
</tr>
<tr>
<td>See Section 4.4.2 for testing recommendations</td>
</tr>
<tr>
<td><strong>Group 3-a: Variable Air Distribution</strong></td>
</tr>
<tr>
<td>Systems where airflow from a single air handler is distributed among multiple dwellings with independent thermostat controls in each dwelling that variably open and close dampers for heated or cooled supply air. Such systems are commonly called Variable Air Volume (VAV) systems.</td>
</tr>
<tr>
<td>See Section 4.4.3 for additional testing requirements</td>
</tr>
<tr>
<td><strong>Group 3-b: Variable Outdoor Air Ventilation</strong></td>
</tr>
<tr>
<td>Systems that seasonally vary outdoor air ventilation for:</td>
</tr>
<tr>
<td>- individual dwellings;</td>
</tr>
<tr>
<td>- multiple dwellings; or</td>
</tr>
<tr>
<td>- the whole building.</td>
</tr>
<tr>
<td>Such systems include those known as: Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative (swamp) cooling systems.</td>
</tr>
<tr>
<td>See Section 4.4.4 for additional testing requirements</td>
</tr>
</tbody>
</table>
EXHIBIT 1  Page 2: INFORMATIVE DESCRIPTIONS OF HEATING, COOLING AND VENTILATION SYSTEMS

**Group 1: Basic Heating and Cooling (HAC)**

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

**HAC Systems:**
Many buildings have forced-air heating and air conditioning (HAC) systems for each dwelling or common use area. These are systems that might be commonly seen in single-family residences.

**Ductless Systems:**
Some buildings have dwellings or common use areas where systems do not have forced-air ducted distribution.

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

**Group 2: Multi-Zone Systems**

Multi-zone systems are those where different air handlers or systems are employed and independently controlled for different areas within the same dwelling or common use area of a building. Such configurations may have been designed originally or added due to modifications of a building or use of an area. Radon concentrations can vary widely from room to room based upon variances in system operations.
Group 3-a: Variable Air Distribution

Variable Air Distribution systems are those where airflow from a single air handler is distributed to multiple dwellings, rooms or common use areas with independent controls within each room or area for duct dampering. Such systems include Variable Air Volume (VAV) systems or systems with fixed volume return vents in each room and controls for dampering supply air.

The normal operation of these systems can cause changes in distribution of radon or ventilation air and can also affect pressure relationships that can enhance or diminish radon entry. Depending on the open or closed operating conditions for supply vents and returns vents, radon concentrations can vary widely from test to test (or room to room).

Group 3-b: Variable Outdoor Air Ventilation

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

Radon concentrations can vary widely from test to test based the volume of outdoor air supplied to a dwelling or room at any given time.
EXHIBIT 2
EXAMPLE: FLOOR PLAN DRAWING/LOG

“X” = Detectors
“D” = Duplicate Detectors
“B” = Field Blank Detectors

Add additional notation as appropriate (i.e. mechanical system notes and continuous or long-term detectors).
EXHIBIT 3
SAMPLE INQUIRY:
SITE LOGISTICS INQUIRY TO CLIENT AND MANAGING STAFF

Dear Client and Managing staff,

Please return this form as soon as possible to help us clarify lines of communication, responsibilities and building details needed for conducting the radon tests.

Your building staff member contacts:

For logistics of onsite activities, contact: _____________________________ Phn# __________
For building/dwelling access, contact: _____________________________ Phn# __________
Other contact title/name: _____________________________ Phn# __________

Client Authorizations

Staff authorized for responding to occupant and public inquiries:

Title/name: _____________________________ Phn# __________
Title/name: _____________________________ Phn# __________

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

Title/name: _____________________________ Phn# __________
Title/name: _____________________________ Phn# __________

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

Client or Authorized Agent Name: _____________________________

Signature: _____________________________ Date _____________

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

Request for Building Information

Please provide floor plan diagrams that identify all ground-contact dwellings and information regarding building foundation types such as slab-on-grade, basement and crawl space areas. Information about upper floor dwellings is also requested.

In addition, please provide answers for the following questions:

( ) Yes ( ) No  Do all dwellings have individual heating or cooling systems?
( ) Yes ( ) No  Do any dwellings have two or more heating or cooling systems?
( ) Yes ( ) No  Are any dwellings or common areas equipped with heating or cooling systems that introduce outside air to the building for seasonal comfort, energy savings or other seasonal need? If yes, provide a detailed description
( ) Yes ( ) No  Are any dwellings or common areas equipped with automated dampers that open or closed heating or cooling system ducts depending on thermostat temperature settings? If yes, provide a detailed description

Please note: Failure to accurately provide this information can result in significant consequences for occupants and cost of retesting if discovered to be needed.
Dear Facilitating Staff,

An important step is being taken to protect the health of building occupants. A radon test is being conducted. Radon is a naturally occurring radioactive gas often found in soil that can be present in some buildings at concentrations greater than recommended. Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in nonsmokers in the United States.

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

Facilitating staff responsibilities:

Initial preparation for testing - Logistics
Information is needed about the building prior to testing, to include: Addresses and floor plan diagrams if possible (e.g., fire-exit diagrams or other floor plan drawings), with descriptions of occupied and unoccupied dwellings; descriptions of heating and cooling systems; and contact information for those personnel responsible for coordination and dwelling access.

Prior Notifications
Notices must be distributed to all tested and non-tested dwellings no later than required by local law for gaining access to a dwelling or not later than the day before testing. Notices should also be posted at this time in publicly accessible areas such as in corridors, elevators and offices. It is also recommended that advance notices be distributed a week or more prior to testing.

Warning: Failure to distribute notices in a timely manner can strain occupant relations and increase testing costs. Occupant interference with the test devices or building conditions can invalidate the test results. Occupant failure to comply with required test conditions is most likely to occur when residents are not properly informed about the necessary test conditions.

Prior building preparations
Facilitating or maintenance staff should prepare for providing access. Facilitating or maintenance staff must ensure that temporary conditions due to repairs, broken windows or doors, or seasonal outside air entry (e.g., adjustments to HVAC units), meet required closed-building conditions 12 hours before testing begins.

Please help to maintain the required test conditions throughout the building
(12 hours before testing and for the duration of the test).

Your building staff member contacts:

Staff authorized for responding to public inquiries: ________________________ Phn# _____________
For logistics of onsite activities, contact: ________________________________ Phn# _____________

For general health information:

Copies of EPA’s *A Citizen’s Guide to Radon* can be found online at [www.epa.gov/radon](http://www.epa.gov/radon).

Test devices are not dangerous in any way and a sample test device is available to view upon request.

We thank you for your cooperation in helping to ensure safe and healthy buildings.
### More Detailed Guidance Provided For Staff

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

<table>
<thead>
<tr>
<th>Keep closed</th>
<th>Windows  (on all levels of the building)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior doors  (except for momentary use)</td>
</tr>
<tr>
<td>Set to normal</td>
<td>Heating and cooling Systems (normal occupied conditions: 65° - 80° F)</td>
</tr>
<tr>
<td>Operate normally</td>
<td>Bathroom fans</td>
</tr>
<tr>
<td></td>
<td>Ventilation components used in all seasons</td>
</tr>
<tr>
<td>Avoid excessive operation</td>
<td>Exhaust systems such as from laundries or for control of fumes from community kitchens</td>
</tr>
<tr>
<td>Outside air dampers closed</td>
<td>Window air conditioners and unit ventilators</td>
</tr>
<tr>
<td>Do not operate</td>
<td>Window fans, whole building ventilation fans or systems that temporarily bring air into or out of the building for seasonal energy savings or comfort</td>
</tr>
<tr>
<td></td>
<td>Fireplaces, including those that burn solid, liquid or gas fuels, unless they are the primary and normal sources of heat for the building</td>
</tr>
</tbody>
</table>

### Actions required at least 12 hours prior to initiating the test

<table>
<thead>
<tr>
<th>All heating/cooling appliances</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functioning and set to run at normal occupied temperatures</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable Outdoor Air Ventilation Systems</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems that seasonally vary outdoor air ventilation for:</td>
<td></td>
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<td>Such systems include: Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative (swamp) cooling systems.</td>
<td></td>
</tr>
<tr>
<td>a) Thermostats shall be set to a normal occupied temperature of 65-80° F (18-27° C) in all ground-contact and upper floor rooms or unique sectors being tested that are served by the system; and</td>
<td></td>
</tr>
<tr>
<td>b) Outside air inlet dampers that are adjusted for seasonal comfort or energy savings shall be set to minimum ventilation settings when systems are designed to provide a degree of outside air ventilation throughout the year. For other system, dampers to outside air shall be closed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All openings to the exterior as a result of incomplete construction, structural defect or disrepair</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close or Seal</td>
<td></td>
</tr>
</tbody>
</table>

**Informational note for testing professionals** — It is recommended to also provide Tables 6.0-A, 6.0-B and 6.0-C for helping to instruct facilitating staff.
Dear Resident,

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

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

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

It is important that staff gains access to place and retrieve radon test detectors

Tentative detector placement:  Day ______________ Date_____________ (please close windows the night before)

Tentative detector pick-up  Day __________ ____ Date_____________ Time_________________

Please help to maintain the required test conditions throughout the building.

<table>
<thead>
<tr>
<th>Required closed-building conditions (12 hours prior the test and during the test).</th>
</tr>
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<tbody>
<tr>
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<td>Windows (on all levels of the building)</td>
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</table>

We will request your signature to help us verify if these conditions were maintained.

For more information:

Copies of EPA’s A Citizen’s Guide to Radon can be found online at [www.epa.gov/radon](http://www.epa.gov/radon).

Test detectors are not dangerous in any way. If you have questions or if you have independently conducted radon testing in your residence, please contact:

Contact Person: ____________________________________________ Phone: _____________________

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

An important step is being taken to protect the health of residents in this building. A radon test is being scheduled for lower floors where the radon might normally be found. Radon is a naturally occurring radioactive gas often found in soil that can be present in some buildings at concentrations greater than recommended.

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

Radon test detectors will be placed in the lower areas of the building and other strategic locations:

Starting Day: ______________ Date_____________ (please close windows the night before)

Ending Day: ______________ Date_____________ Ending Time: Close of business hours.

Please help to maintain the required test conditions throughout the building.

<table>
<thead>
<tr>
<th>Required closed-building conditions (12 hours prior the test and during the test).</th>
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<tbody>
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<tr>
<td>Fireplaces, including those that burn solid, liquid or gas fuels, unless they are the primary and normal sources of heat for the building</td>
</tr>
</tbody>
</table>

We will request your signature to help us verify if these conditions were maintained.

Even though ground contact areas are tested for initial surveys, you are encouraged to consider testing your own dwelling for personal verification of low radon exposures. Inexpensive home test detectors are readily available and tests can be conducted at any time that the required closed-building conditions are a normal condition for the building.

For more information:

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

If you have questions or if you have independently conducted radon testing in your residence, please contact:

Contact Person: ____________________________ Phone: ____________________________

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

Dear Residents,

An important step is being taken to protect your health. Radon testing is being conducted for this building. Radon is a naturally occurring radioactive gas that can be present in some buildings at concentrations greater than recommended. Testing for radon is recommended for all homes. Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer for nonsmokers in the United States. The only way to know what the radon concentrations are for any building is to test.

Radon testing is scheduled for:

Building(s): __________________________________________
Building Area(s): __________________________________________

Test Deployment: Day __________ Date ___________ (please close windows the night before)
Test Completion: Day __________ Date ___________ Time: Before close of business hours

Please help to maintain the required test conditions throughout the building.

<table>
<thead>
<tr>
<th>Required closed-building conditions (12 hours prior to the test and during the test).</th>
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</tr>
<tr>
<td><strong>Exterior doors</strong> <em>(except for momentary use)</em></td>
</tr>
<tr>
<td><strong>Set to normal</strong></td>
</tr>
<tr>
<td><strong>Operate normally</strong></td>
</tr>
<tr>
<td><strong>Ventilation components used in all seasons</strong></td>
</tr>
<tr>
<td><strong>Avoid excessive operation</strong></td>
</tr>
<tr>
<td><strong>Outside air dampers closed</strong></td>
</tr>
<tr>
<td><strong>Do not operate</strong></td>
</tr>
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</tbody>
</table>

For more information:

Copies of EPA’s *A Citizen’s Guide to Radon* can be found online at [www.epa.gov/radon](http://www.epa.gov/radon).

If you have questions or if you have independently conducted radon testing in your residence, please contact:

Contact Person: __________________________________________ Phone: _______________________

We thank you for your cooperation in helping to ensure a safe and healthy building.
**RADON TEST IN PROGRESS**

| Required closed-building conditions | Windows & Exterior doors  
(12 hours prior the test and during the test). |
|-------------------------------------|---------------------------------------------------------------------|
| Keep closed                         | Windows & Exterior doors  
(Except for momentary use)                                           |
| Set to normal                       | Heating & Cooling systems  
(Kept between about 65° - 80° F)                                    |
| Operate normally                    | Bathroom fans                                                       |
|                                    | Other ventilation units  
That are used in all seasons                                           |
| Avoid excessive operation           | Exhaust systems  
Such as from laundries or for control of  
Fumes from community kitchens                                           |
| Outside air dampers closed          | Window air conditioners  
And unit ventilators                                                   |
| Do not operate                      | Window fans, whole building fans or other  
Systems that temporarily bring air into  
Or out of the building for seasonal  
Energy savings or comfort                                                |
|                                    | Fireplaces that burn  
Solid, liquid or gas fuels,  
Unless they are the primary sources of heat for the building         |

**Radon Test Device**

Do not discard or disturb

For questions, call ________________

**Radon Test Device**

Do not discard or disturb

For questions, call ________________

**Radon Test Device**

Do not discard or disturb

For questions, call ________________

**Radon Test Device**

Do not discard or disturb

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Do not discard or disturb

For questions, call ________________

**Radon Test Device**

Do not discard or disturb

For questions, call ________________

**Radon Test Device**

Do not discard or disturb

For questions, call ________________
Radon Survey in Progress

Dear Resident,

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

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

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

**It is important that required test conditions stated below are maintained.**

- Please sign this form and add any comments to help ensure accurate tests.
- Please leave this signed form with the test kit or return to: ____________________________

| Declaration of Observed Compliance: To the best of my knowledge, the required conditions stated below were maintained during the test. |
| Occupant Signature: ____________________________ Date _____________ |
| Address: ________________________________________________________________________________ |
| Comments if any: _________________________________________________________________________ |

- **Detector Pick-up** Day ____________ Date ____________ Time ____________

| Required closed-building conditions (12 hours prior the test and during the test). |
| Keep closed | Windows (on all levels of the building) |
| Exterior doors (except for momentary use) |
| Set to normal | Heating and cooling systems (normal occupied conditions: 65° - 80°F) |
| Operate normally | Bathroom fans |
| | Ventilation components used in all seasons |
| Avoid excessive operation | Exhaust systems such as from laundries or for control of fumes from community kitchens |
| Outside air dampers closed | Window air conditioners and unit ventilators |
| Do not operate | Window fans, whole building ventilation fans or systems that temporarily bring air into or out of the building for seasonal energy savings or comfort |
| | Fireplaces, including those that burn solid, liquid or gas fuels, unless they are the primary and normal sources of heat for the building |

If you have questions or if you have independently conducted radon testing in your residence, please contact:

Contact Person: ____________________________ Phone: ____________________________

We thank you for your cooperation in helping to ensure safe and healthy homes.
Radon Survey in Progress

Dear Resident,

An important step is being taken to protect the health of residents in this building. A radon test is being conducted for lower floors where the radon might normally be found. Radon is a naturally occurring radioactive gas often found in soil that can be present in some buildings at concentrations greater than recommended.

Starting Day: ______________ Date ______________ (please close windows the night before)

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

Please help to maintain the required test conditions throughout the building.

Please sign this form and add any comments to help ensure accurate tests.

Please leave the signed form with the test kit or return to: ___________

Declaration of Observed Compliance: To the best of my knowledge, the required conditions stated below were maintained during the test.

Occupant Signature: __________________________ Date __________________

Address: ____________________________________________________________

Comments if any: ____________________________________________________

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

<table>
<thead>
<tr>
<th>Keep closed</th>
<th>Windows (on all levels of the building)</th>
</tr>
</thead>
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Copies of EPA’s A Citizen’s Guide to Radon can be found online at [www.epa.gov/radon](http://www.epa.gov/radon).

If you have independently conducted radon testing in your residence or have any questions, please contact:

Contact Person: __________________________ Phone: __________________________

We thank you for your cooperation in helping to ensure safe and healthy homes.
Advisory—The information contained in this guidance document does not contain requirements necessary for conformance to the MAMF standard and is not part of this ANSI/AARST American National Standard (ANS). The information contained in this guidance document has not been processed in accordance with ANSI’s requirements for an ANS. As such, this guidance document may contain material that has not been subjected to public review or a consensus process.
CG 1.1 Planning and Preparation
Planning to test your building for radon requires a basic understanding of the radon testing process and the steps that are necessary to ensure that your radon test results are reliable.

Poorly designed studies can lead to unnecessary expense, disruption and misinterpretation of data.

To plan for radon testing, you will need to:

a. Become familiar with testing methods
   (See Section 2 of this Companion Guidance);

b. Become familiar with building conditions that are required to achieve reliable radon tests
   (See MAMF Section 6);

c. Investigate whether previous tests have been conducted and collect any available test results; and

d. Become familiar with guidance for when radon reduction is recommended.
   (See Section CG 1.9 of this Companion Guidance);

To prepare for radon testing, you will need to:

a. Gather building information to include floor plan diagrams and descriptions of the different heating and cooling systems in the building(s).
   (MAMF Exhibit 3);

b. Design, implement and document a plan for communicating information about radon testing activities.
   (MAMF Exhibits 2 and 3 and related exhibits);

c. Consult with a radon professional to determine an appropriate and practical testing strategy that meets the requirements of this standard's protocols.
   A radon measurement professional can help assess the nature of your building complex and help you choose a responsible and reliable measurement plan; and

d. Review logistics and estimate the number of detectors, including those for quality control (QC) requirements, when evaluating costs and competitive bids from companies providing radon testing services.

CG 1.2 Procedural Order of Events

1. Proposals
To provide price quotes, the measurement professional will need to:
   a. identify the test strategy that fits the situation,
   b. identify how many dwellings will be tested, and
   c. identify heating, cooling and ventilation system designs for all testing locations;
   (See MAMF Sections 3 and 4)

2. Preparation
Property managers and testing professionals need to:
   a. establish lines of communication (i.e., a communication plan),
   b. identify who is responsible for decisions during and after the testing process,
   c. identify facilitating staff,
   d. establish and implement a plan for distribution of notices prior to testing, and
   e. establish and implement a plan, if needed, for facilitating staff to check windows or adjust ventilation systems the day before testing.

3. Conducting the testing
The testing professional(s) will need access to all dwellings identified for testing for:
   a. test detector placement,
   b. test detector retrieval, and
   c. other access events such as for dwellings that were not accessed or if detectors were missing.

4. Initial test reports
Property managers will often need to make decisions that have monetary and timeliness considerations, to include:
   a) decisions about distributions and disclosures of test reports and test data,
   b) follow-up testing procedures, and
   c) fixing the building if test data indicates radon concentrations that are equal or greater than the action level, e.g., 4 pCi/L.

5. Post-mitigation testing if needed
At a minimum, repeat procedures as conducted for a first-test phase (Step 1 of the Extended test protocol). Once acceptable radon concentrations are indicated, institute an operation, maintenance and monitoring plan that includes retesting every two years to verify radon remains at acceptable concentrations.
CG 1.3 Communication Plan

Develop a specific and written “Radon Risk Management and Communication Plan” for disseminating information throughout the process to all affected parties. Include senior staff, appropriate communications staff, maintenance staff, and a radon measurement professional when developing the communication plan. This plan should be agreed to and signed by the responsible parties.

CG 1.3.1 Prior to the test:

a. Develop notices (with general information and instructions) that are specific for each affected audience, including:
   1) Facilitating staff
      (See MAMF Exhibit 4 for a sample notice), and
   2) Dwelling occupants.

b. Specify the staff members responsible for onsite activities.
   - Identify who is responsible for developing contingency plans for unexpected challenges during the testing, and
   - Specify additional communication paths between senior staff, facilitating staff, maintenance staff and the professional radon service provider.

c. Specify the procedure for distribution of radon test data including:
   - Identify who is designated to receive data or reports from the radon measurement professional,
   - Identify what situations, if any, warrant reporting interim and incomplete test results prior to completion of all test phases.
      (See MAMF Sections 2.2.2 and 4.6.2 for topics that should be decided prior to any situation where follow-up testing is a component of the chosen test strategy),
   - Identify who is granted permission to respond to public inquiries and their contact information, and
   - Specify the procedure and mechanism for disclosing the radon test results and the person(s) allowed to discuss test results with occupants.

CG 1.3.2 Pre-test notifications:

Distribute notices of radon testing at least 2 weeks in advance of beginning testing and again a few days before the test to appropriate staff and occupants.

Poor communications to occupants prior to testing can lead to test disruption and unusable data, creating unnecessary expense and aggravation.

(See MAMF Exhibits 5 through 9 for sample notification forms.)

All notices should include:

a. The likely placement and retrieval dates/times;

b. A statement of the reasons for the testing and its role in helping ensure the occupants’ health and safety, and

d. Contact information for questions and information on how concerned parties can find radon risk information.

Facilitating staff notices should also include:

(See MAMF Exhibit 4 for a sample notice)

e. Instructions for maintaining proper test conditions including all applicable test condition requirements prior to and during the testing;

f. A warning that failure to maintain required building conditions or disturbing test devices might cause test results to be unreliable or invalid;

g. Contact information for senior staff, facilitating staff and the professional radon service providers;

h. The names and contact information for those granted permission to discuss test procedures and results with occupants, parents or other parties; and

i. Literature that introduces radon such as found in the MAMF introductory foreword or information on where concerned parties can learn more about radon.

CG 1.3.3 After the test – a recommendation

Full public disclosure of radon test results for multifamily buildings is strongly recommended and in some localities required by law. Failure to disclose test results can deprive current and future occupants of information necessary to avoid risk, thereby increasing the culpability of building owners and managers.
CG 1.4 Selecting a Radon Service Provider

Use professionals that have demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon measurement in multifamily buildings:

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

b) as required by statute, state licensure or certification program, where applicable.

In the United States, a list of licensed or certified providers can be found at the State Radon Office (www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information#stateradon) or at nationally recognized certifying programs (www.aarst-nrpp.com or www.nrsb.org).

Otherwise, conduct customary contracting procedures such as verifying certification status and any history of unresolved complaints or regulatory actions.

CG 1.5 Test Devices

All equipment used for measuring radon must meet requirements of the local jurisdiction where the testing is conducted or be listed by a nationally recognized radon proficiency program (e.g., the NRPP or NRSB) if the jurisdiction has no device verification program.

CG 1.6 Role of a Facility’s Personnel

Because the facility’s personnel frequently have knowledge of the building and the occupants, they can play a key role during the testing process, especially in planning and scheduling. By providing access to rooms and supplying floor plans when available, the facility personnel can help the measurement service providers to quickly identify appropriate testing locations, and plan testing strategy.

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

CG 1.7 Documenting the Testing Program

A record of the testing program should be maintained by the client for future reference. This record should contain the following information:

a) A copy of the final report submitted by the measurement service that conducted the tests and the measurement service’s statement outlining any recommendations concerning retesting or mitigation. (MAMF Section 7 describes appropriate reports.)

b) All correspondence between you and the measurement service.

CG 1.8 When to Test

General: Closed-building protocol conditions in accordance with MAMF Section 6 are required for short-term test durations of 2 to 90 days. For testing programs where the occupants may not be active participants in the testing process, actions must be considered to help ensure closed-building conditions for short-term tests. Choosing a time of year when required closed-building conditions are a normal condition will aid in ensuring reliable measurements.

Real-Estate Transactions: Testing for radon prior to every transfer of a residential dwelling to a new owner is recommended. Regardless of whether a building has been tested before, additional measurements help to ensure that conditions, including structure and ventilation, have not changed. Property owners should also consider testing in advance of initiating a real-estate sale so that the transaction will not be delayed.

Non-Real-Estate Testing: Although radon testing can begin at any time during the year, consider conducting measurements during a time of year when required closed-building conditions are the normal conditions. For example: In cooler climate regions it is recommended that you schedule short-term testing during colder months of the year (i.e., heating season).

Where Little Evidence Indicates Radon Concerns:

Regardless of where one lives, people do not expect to find radon hazards in local homes and buildings. However, hazardous radon concentrations can be found virtually anywhere on earth as witnessed in virtually all national and international survey data. Published survey maps inform citizens about local averages but are not capable of identifying which buildings pose a hazard.

For this reason, health authorities have recommended all residential buildings be tested, as well as buildings where individuals spend a significant portion of time.

Regions that may experience unusual or sizable variations in indoor radon concentrations:

Hot-temperate climate zones and regions with karst geology are examples where longer test periods or repeated tests across different seasonal conditions can be important for properly characterizing radon hazards. Health authorities in the United States have recommended short-term testing to quickly identify if there is an urgent situation. But keep in mind:

a) Short-term testing does not need to be limited to a few days. Short-term testing is defined by requirements to keep closed-building conditions for test periods up to 90 days.

b) Long-term test periods (91 days or longer) should reflect yearlong conditions in terms of both the percentage of time across the year that a building is kept closed and seasonal temperature variability.
CG 1.9 Actions Based Upon Test Results

**Action Levels:** Countries worldwide have adopted Action Levels for radon exposures. Most are similar to the 4 pCi/L (148 Bq/m³) action level recommended by the U.S. Environmental Protection Agency (EPA).

The Action Level observed should, at a minimum, comply with guidance of the country, state or jurisdiction where the test is being conducted.

As with any health threat from radioactivity, there is no worldwide specific action levels for worker safety. The Health Administration (OSHA) and similar authorities worldwide specify action levels for worker safety. The World Health Organization (WHO) recommends a reference level for action at 100 Bq/m³ (2.7 pCi/L) as a goal for economically developed countries.

**U.S. Action Level:** The following Action Level descriptions reflect guidance from the USEPA:

**4 pCi/L (148 Bq/m³) or greater**

If the testing indicates radon concentrations equal to or greater than 4 pCi/L in any dwelling, exercise facility, meeting room, dining area or other common area, reduce the radon to below 4 pCi/L. The higher the radon concentration, the more quickly action should be taken to reduce the concentrations.

**Below 4 pCi/L (148 Bq/m³)**

Radon concentrations below 4 pCi/L still pose a risk to occupants. Consider fixing the building if test results indicate radon concentrations between 2 and 4 pCi/L (74 and 148 Bq/m³). Note that reducing and accurately confirming radon concentrations of about 2 pCi/L or below may be difficult. If test results are below the action level, confirm the low results by testing again, at least every 5 years and whenever significant changes to the building's structure or mechanical systems occur.

**For Non-occupied Rooms/Enclosed Spaces**

Reduce the radon concentration if:

1. testing indicates radon concentrations equal to or greater than 4 pCi/L in these locations;  
   **AND**
2. either (a) these areas are occupiable with little or no modification, or (b) these areas serve as a source of radon into occupied areas of upper story floors that have radon concentrations equal to or greater than 4 pCi/L.

CG 1.10 Mitigation

**Timing:** How quickly to begin the mitigation process will depend on the initial radon concentration detected. Radon concentrations of more than twice the action level e.g., more than 8 pCi/L (296 Bq/m³) require a more rapid response.

**Methods:** Become familiar with all mitigation methods and required practices as thoroughly described in the most current version of ANSI/AARST RMS-MF "Radon Mitigation Standards for Multifamily Buildings". For the latest AARST documents see: www.aarst.org

**The Need for Professional Mitigation Guidance:**

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

To successfully lower radon concentrations with confidence, the management team, contractor or contracting team needs to include individuals with experience in radon mitigation, and an individual who has demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon mitigation of multifamily buildings:

a) as established in certification requirements of the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); and
b) as required by statute, state licensure or certification program, where applicable.

Conditions in the entire building must be evaluated. Diagnostic procedures to evaluate air pressure relationships within and under a building are needed to identify the appropriate radon reduction technique and design. A professional is also needed to ensure compliance with building codes and applicable standards.

**CG 1.10.1 Retests after mitigation:**

To provide an initial measure of radon reduction system effectiveness, conduct a short-term measurement no sooner than 24 hours after a radon reduction system is operational and within 30 days after installation of system. Conduct the test in the same location as the pre-mitigation test location or the lowest livable area. Also, conduct a post-mitigation test in the lowest livable area above any crawlspace that is structurally isolated. It is recommended that additional measurements be conducted in the lowest livable area above each other unique structural area. Additional testing should be conducted at least every two years in the areas that were mitigated to ensure that the system remains effective; testing may be conducted as often as desired.
CG 1.11 Retesting When Tests Have Indicated Low Radon Concentrations

Retest all building(s) at least every 5 years and in conjunction with any sale of a building.

When tests indicate low concentrations, consider confirming low concentrations by repeating tests during different seasons and weather conditions to account for possible seasonal variations. Many factors can cause indoor radon concentrations in a building to change over time. Changes can occur due to renovation work including energy upgrades. Pressure relationships can change if HVAC equipment is added, removed, replaced, operated differently or improperly maintained. New openings to the earth may develop due to settling or deterioration of the building. These changes may produce variations in radon concentrations compared to previous tests.

In addition, be certain to test again 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;
- Heating or cooling systems are altered with changes to air distribution or pressure relationships;
- Ventilation is altered by extensive weatherization, changes to mechanical systems or comparable procedures;
- Sizable openings to soil occur due to:
  - ground water or slab surface water control systems are added or altered (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.); or
  - natural settlement causing major cracks to develop;
- Earthquakes, construction blasting or formation of sink holes nearby; or
- A mitigation system is altered, modified or repaired.

CG 2.1 General Descriptions

Integrating or Equilibrating Devices: A radon measurement system in which the sampling detector and analysis system often do not function as a stand-alone unit. Integrating devices include electret ion chambers, alpha track monitors and continuous monitors that are not set to, or are incapable of, recording radon concentration in time increments of 1 hour or less. Equilibrating devices include activated charcoal kits and liquid scintillation vials. Integrating and Equilibrating detectors often require laboratory analysis.

Continuous Devices: Test devices that record reviewable measurements of radon or radon decay products (progeny) concentration in time increments of one hour or less.

Abbreviations for Devices referenced in this document

<table>
<thead>
<tr>
<th>Equilibrating Devices</th>
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<tbody>
<tr>
<td>AC</td>
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<td>CW</td>
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<tr>
<th>Other Devices</th>
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Future technologies

CG 2.2 Equilibrating Devices

**AC – Activated Charcoal Devices**

Activated Charcoal (AC) devices are equilibrating devices. The charcoal within the detectors has been activated to increase its surface area, which
increases the ability to adsorb gases. The equilibrating nature of the activated charcoal allows continual adsorption and desorption of radon. During the entire measurement period (typically 48 hours to 7 days), the adsorbed radon undergoes radioactive decay. ACs should be promptly returned to the laboratory after the exposure period within the time frames specified by the laboratory. When appropriate, consider using a mail service that guarantees delivery within two to three days. AC detectors are analyzed by gamma-ray spectroscopy devices that measure the emissions of gamma rays from two short-lived decay products of radon, $^{214}\text{Pb}$ and $^{214}\text{Bi}$.

**LS – Charcoal Liquid Scintillation Devices**

Charcoal liquid scintillation (LS) devices are equilibrating devices that function on the same principle as AC devices. LS detectors adsorb radon onto the charcoal in a vial. LS detectors must be resealed and sent to the laboratory for analysis promptly after the exposure period by service that guarantees delivery within two to three days. They are called “liquid scintillation” devices because they are analyzed by mixing the charcoal containing the radon with an organic “cocktail” and then counting, in a liquid scintillation counter, light pulses emitted due to the emission of alpha and beta particles from radon and its short-lived decay products.

**CG 2.3 Integrating Devices**

**EL/ES – Electret Ion Chambers**

Electret ion chamber (EL/ES) devices are integrating devices that allow radon to diffuse into a chamber through a filter. Radiation emitted from the decay of radon and its decay products produces charged particles (ions) within the chamber. The negative ions are attracted to the positively charged electret and discharge it. The electret is removed from the canister and its voltage measured with a special surface electrostatic voltmeter both before and after the exposure period. The difference between these two voltage readings is used to calculate the average radon concentration.

EL/ES detectors are designed to measure for short periods of time (e.g., 2 to 7 days) or for long periods of time (e.g., up to 12 months). The types of electret (i.e., short or long-term) and chamber volume determine the usable measurement period. The electret readings are affected by ambient gamma radiation ionizing air inside the chamber, and the readings must be corrected for external gamma-rays.

**AT – Alpha Track Devices**

An alpha track (AT) device is an integrating device consisting of a small piece of plastic or film (the sensor) enclosed in a housing with a filtered opening. Radon diffuses through the filter into the housing where it undergoes radioactive decay. This decay produces alpha particles that strike the sensor and generate submicroscopic damage called alpha tracks. The damaged portions of the plastic can be made visible by etching in a caustic solution, because the damaged areas are more soluble in caustic than the undamaged plastic. The etched areas can be seen using a microscope. The tracks are typically counted using computer recognition and automated scanning. The number of tracks per unit area is proportional to the integrated average radon concentration in pCi-days/Liter. AT’s are most commonly used for medium to long-term tests up to one year in length.

**EID – Electronic Integrating devices**

Electronic Integrating devices (EID) are most often seen to use sensors that are similar to those in continuous radon monitors but cannot, or are not set to integrate, record and produce reviewable readings in time increments of one hour or less.

**CG 2.4 Continuous Monitors**

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

These continuous monitors use various types of sensors. CRs measure radon gas concentrations. CWs measurement the working level concentration of radon decay products and require a pump to sample air containing radon decay products onto a filter assembly.

If a device cannot integrate, record and produce reviewable readings in time increments of one hour or less, or is not set to record readings each hour, then the device is functioning as a passive integrating or equilibrating device and is not considered a continuous monitor under these protocols.

**CG 2.5 Other Devices:**

Devices that may be developed that use various other sensors and technologies for integrating data over time. All devices used for measuring radon in buildings shall meet state requirements and be approved by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). All devices shall be used in strict accordance with manufacturer’s instructions.
**CG SECTION 3**

**DESCRIPTIONS OF DEVICE QUALITY CONTROL**

**CG 3.1 General**

Terminology associated with *quality control (QC)* is briefly explained below. Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project. In lieu of other consensus protocols that may be developed, see EPA Guidance on Quality Assurance (402-R-95-012, October 1997). Additional specific requirements for each device can be found in EPA's "Indoor Radon and Radon Decay Product Measurement Device Protocols." Written QA plans are required of radon measurement professionals and laboratories that are state licensed or certified by NRPP or NRSB.

**CG 3.2 Duplicate (Collocated) Measurements**

Duplicates are pairs of detectors or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between detectors or monitors. Some variation between the results of each detector is expected. However, if the variation is unusually large, it may indicate problems in the measurement system. Duplicates are typically deployed at a rate of 10% of all measurement locations.

The following table includes example guidance for understanding, documenting and monitoring precision error. The percentage of difference between the duplicate results, as shown in the table, is typically calculated in terms of Relative Percent Difference (RDP).

<table>
<thead>
<tr>
<th>If results are</th>
<th>Expected Precision</th>
<th>Within Control</th>
<th>Warning</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 4 pCi/l</td>
<td>0 - 14%</td>
<td>0 - 27%</td>
<td>28 - 36%</td>
<td>&gt; 36%</td>
</tr>
<tr>
<td>2.0 - 3.9 pCi/l</td>
<td>0 - 25%</td>
<td>0 - 49%</td>
<td>50 - 67%</td>
<td>&gt; 67%</td>
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</tbody>
</table>

*Relative Percent Difference (calculations):*

The RDP between a pair of duplicate measurement detectors is calculated by dividing the difference between the two results by the average of the two results and multiplying by 100.

\[
\text{RDP} = \left(\frac{|X_1 - X_2|}{X_{\text{avg}}} \right) \times 100\%
\]

where:

- \(X_1\) = result of detector 1
- \(X_2\) = result of detector 2
- \(|X_1 - X_2|\) = absolute value of the difference between detectors 1 and 2
- \(X_{\text{avg}}\) = average concentration = \((X_1 + X_2)/2\)

**Example:**

- \(X_1 = 9.0\) and \(X_2 = 8.0\)
- \(\text{RDP} = \left(\frac{|9 - 8|}{8.5} \right) \times 100\% = 1/8.5 \times 100\% = 11.8\%\)

The RDP of each new pair of duplicate measurements should be examined carefully and plotted on a control chart to quantitatively evaluate the precision of a measurement system across time.

If duplicate results fall outside of control limits, an investigation to identify the cause may be warranted and could include repeating the measurements. It is important to recognize that a few high precision errors do not necessarily mean that the measurement system is flawed. However, if analysis reveals repeated results at a rate that is outside established control limits, stop making measurements and identify and correct the problem. For measurement systems that entail multiple standalone monitors, the investigation may quickly identify if one or more devices have developed a problem. For measurement systems or projects that entail 20 or more duplicate measurements within a month: If more than 5% of the duplicates are in the warning range or more than 1% of the duplicates are outside of control limits, the measurement system is generally considered “out of control” and all measurements are questionable.

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

**CG 3.3 Blank Measurements**

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

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

However, additional blank detectors may be required for a specific testing program such as discussed herein for schools and large buildings. See MAMF Section 5.0.

Consult with the manufacturer/Laboratory to insure detector-specific procedures approved by the manufacturer/laboratory are used when conducting blank measurements. The blanks are then shipped with the exposed detectors so that the laboratory cannot distinguish them.
Blanks can help identify concerns that may develop at various junctures during the chain of custody for detectors, such as:

- **Lab-transit blanks** are those returned to the laboratory immediately in order to evaluate laboratory quality yet also serve to evaluate if any unexpected exposures occurs during shipping or handling.

- **Office blanks** are those that remain in office locations where detectors are stored or handled in order to additionally evaluate any unexpected exposures that might result in those locations. Detectors should be stored and handled in a known low-radon environment.

- **Field blanks** are those that accompany the onsite sampling detectors in order to evaluate any unexpected exposures that might result onsite or from handling procedures.

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

**CG 3.4 Spiked Measurements**

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

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

The results from spikes are compared to the known value provided by the reference facility where they are spiked using the formula for Relative Percent Error (RPE). The RPE is plotted on a control chart. If the result of a spike differs greatly from the spike's known concentration, it may indicate that the detectors are defective or the laboratory procedures are faulty. **EPA 402-R-95-012, Guidance on Quality Assurance** provides guidance on how to set warning and control limits. In general, the expectation is that the values of RPE fall between +10% and -10%, but the entire range of +20% to -20% is considered “in control.” Outside of +/-20% but inside +/-30% is the warning level and outside of +/-30% is the control limit.

See **MAMF Section 9 “Definition of Terms”** for information on calculating Relative Percent Error (RPE).

**CG 3.5 Quality Control for Continuous Monitors**

Continuous radon monitors require calibration and background checks within the timeframe recommended and at facilities approved by certification requirements, state licensure requirements or the manufacturer’s recommendation, whichever is more stringent. Annual calibrations are commonly a minimum requirement. Cross-checks should be conducted at least every six months. Analytical service providers should perform side-by-side measurements in approximately 10% of the total number of CRM measurements. The agreement of duplicate results are evaluated using the RPD calculation.
CG SECTION 4 CHAIN OF CUSTODY  Figure 4.1 SAMPLE DATA LOG

This form is an example and not intended to prescribe all methods that may be desired or required for tracking.

Form# _____ / Rev# _______ / Effective Date ______

Building Name: ________________________________

Testing Contractor: ________________________________

Address: ____________________________________________

Contractor Phone: ________________________________

________________________________________________________

Contact Name: ________________________________

________________________________________________________

Contact Phone: ______________________________________

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Apartment / Room No.</th>
<th>Room</th>
<th>Placement Location</th>
<th>Start Date</th>
<th>Start Time</th>
<th>Stop Date</th>
<th>Stop Time</th>
<th>Floor</th>
<th>Comments</th>
<th>Tech. Place</th>
<th>Tech. PU</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Indicate Time Standard used: [ ] AM-PM [ ] Military  Time Zone: _____________

Technician __________________________ Initials __________ License# __________

Technician __________________________ Initials __________ License# __________

Technician __________________________ Initials __________ License# __________
### CG SECTION 4  CHAIN OF CUSTODY  Figure 4.2 SAMPLE OF DATA ENTRY

**Form# RT1001 / Rev# 2 / Date 09-20-06**

**Building Name:** ______________________________________
**Address:** ____________________________________________

**Testing Contractor:** _____________________________
**Contractor Phone:** ______________________________

**Contact Name:**  ________________________________
**Contact Phone:** ________________________________

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Apartment / Room No.</th>
<th>Room</th>
<th>Placement Location</th>
<th>Start Date</th>
<th>Start Time</th>
<th>Stop Date</th>
<th>Stop Time</th>
<th>Floor</th>
<th>Comments</th>
<th>Tech. Place</th>
<th>Tech. PU</th>
</tr>
</thead>
<tbody>
<tr>
<td>12345</td>
<td>100</td>
<td>Family</td>
<td>S Wall</td>
<td>2/5/2008</td>
<td>11:00 a.m.</td>
<td>2/9/2008</td>
<td>11:30 a.m.</td>
<td>1</td>
<td></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12346</td>
<td>100</td>
<td>Family</td>
<td>S Wall - D</td>
<td>2/5/2008</td>
<td>11:02 a.m.</td>
<td>2/9/2008</td>
<td>11:30 a.m.</td>
<td>1</td>
<td></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12347</td>
<td>104</td>
<td>Family</td>
<td>S Wall</td>
<td>2/5/2008</td>
<td>11:08 a.m.</td>
<td>2/9/2008</td>
<td>11:35 a.m.</td>
<td>1</td>
<td></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12348</td>
<td>106</td>
<td>Family</td>
<td>S Wall</td>
<td>2/5/2008</td>
<td>11:14 a.m.</td>
<td>2/9/2008</td>
<td>11:37 a.m.</td>
<td>1</td>
<td><strong>D</strong></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12349</td>
<td>106</td>
<td>Bedroom</td>
<td>B</td>
<td>2/5/2008</td>
<td>11:15 a.m.</td>
<td>2/9/2008</td>
<td>11:37 a.m.</td>
<td>1</td>
<td></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12350</td>
<td>108</td>
<td>Family</td>
<td>N Wall</td>
<td>2/5/2008</td>
<td>11:22 a.m.</td>
<td>2/9/2008</td>
<td>11:40 a.m.</td>
<td>1</td>
<td>Detector was moved</td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12351</td>
<td>110</td>
<td>Bedroom</td>
<td>Night Stand</td>
<td>2/5/2008</td>
<td>11:25 a.m.</td>
<td>2/9/2008</td>
<td>11:42 a.m.</td>
<td>1</td>
<td></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12352</td>
<td>112</td>
<td>Family</td>
<td>Bookshelf</td>
<td>2/5/2008</td>
<td>11:30 a.m.</td>
<td>2/9/2008</td>
<td>11:45 a.m.</td>
<td>1</td>
<td><strong>B</strong></td>
<td>SH</td>
<td>SH</td>
</tr>
<tr>
<td>12353</td>
<td>114</td>
<td>Living</td>
<td>N Wall</td>
<td>2/5/2008</td>
<td>11:33 a.m.</td>
<td>2/9/2008</td>
<td>11:50 a.m.</td>
<td>1</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12354</td>
<td>116</td>
<td>Family</td>
<td>E Wall</td>
<td>2/5/2008</td>
<td>11:39 a.m.</td>
<td>2/9/2008</td>
<td>11:53 a.m.</td>
<td>1</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12355</td>
<td>118</td>
<td>Living</td>
<td>E Wall</td>
<td>2/5/2008</td>
<td>11:42 a.m.</td>
<td>2/9/2008</td>
<td>11:56 a.m.</td>
<td>1</td>
<td><strong>D</strong></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12356</td>
<td>120</td>
<td>Bedroom</td>
<td>Dresser</td>
<td>2/5/2008</td>
<td>11:45 a.m.</td>
<td>2/9/2008</td>
<td>12:00 p.m.</td>
<td>1</td>
<td>Window Open</td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12357</td>
<td>202</td>
<td>Family</td>
<td>S Wall</td>
<td>2/5/2008</td>
<td>11:55 a.m.</td>
<td>2/9/2008</td>
<td>12:08 p.m.</td>
<td>2</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12358</td>
<td>212</td>
<td>Family</td>
<td>Corner Table</td>
<td>2/5/2008</td>
<td>12:00 p.m.</td>
<td>2/9/2008</td>
<td>12:11 p.m.</td>
<td>2</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
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<td>306</td>
<td>Living</td>
<td>S Wall</td>
<td>2/5/2008</td>
<td>12:04 p.m.</td>
<td>2/9/2008</td>
<td>12:15 p.m.</td>
<td>3</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12360</td>
<td>318</td>
<td>Bedroom</td>
<td>E Wall</td>
<td>2/5/2008</td>
<td>12:08 p.m.</td>
<td>2/9/2008</td>
<td>12:18 p.m.</td>
<td>3</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
<tr>
<td>12361</td>
<td>318</td>
<td>Bedroom</td>
<td>E Wall - D</td>
<td>2/5/2008</td>
<td>12:10 p.m.</td>
<td>2/9/2008</td>
<td>12:18 p.m.</td>
<td>3</td>
<td></td>
<td>GJ</td>
<td>SH</td>
</tr>
</tbody>
</table>

* “D” = Duplicate
* “B” = Blank
* “S” = Spike

**Indicate Time Standard used:** [X] AM-PM  [ ] Military
**Time Zone:** Central Daylight

**Technician** George Jackson  **Initials** GJ  **License#** G100225

**Technician** Sam Hayes  **Initials** SH  **License#** G107809

**Technician** ______________________  **Initials** ________  **License#** ________
This example form might be used for documenting education that is provided by or found acceptable to a Qualified Measurement Professional when they permit uncertified support staff to aid in conducting tests. It is prudent to keep records of staff training with other quality control records retained for Quality Assurance Plan needs.

The following checklist is an example of a written training document used by a qualified measurement professional (QMP) when a large project requires the use of assistance by non-certified individuals for the placement or retrieval of the radon measurement devices. The intent of this example is to demonstrate areas of knowledge necessary for the non-certified assistants and to act as a template that the QMP can develop to ensure consistent training of support staff and to obtain acknowledgement from the support staff that adequate training was provided.

<table>
<thead>
<tr>
<th>Initials</th>
<th>Scope of Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>I have been instructed and understand:</td>
<td></td>
</tr>
<tr>
<td>___</td>
<td>the manufacturer's instructions for placing and retrieving devices, including duplicate and field blank devices.</td>
</tr>
<tr>
<td>___</td>
<td>the specific placement location for each residential unit type and non-residential area specific to the project site.</td>
</tr>
<tr>
<td>___</td>
<td>closed building conditions and other measurement requirements for the specific project site.</td>
</tr>
<tr>
<td>___</td>
<td>the procedures for completing the device placement log and maintaining proper chain of custody.</td>
</tr>
<tr>
<td>___</td>
<td>the procedures to follow when a question arises on the project site.</td>
</tr>
<tr>
<td>___</td>
<td>the QMP’s communication policy regarding radon health risks and protocol.</td>
</tr>
</tbody>
</table>

_________________________________________________________

Acknowledgment of Non-Certified Person / Date

_________________________________________________________

Witnessed by Qualified Measurement Professional / Date
Correlation of Tasks and Technical Skills Commonly Associated With Placing and Retrieving Detectors

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

<table>
<thead>
<tr>
<th>Task</th>
<th>Instructions or Training associated with each task:</th>
<th>QMP’s Required Outcome</th>
</tr>
</thead>
</table>
| Section 2.1 Managing detectors during detector placement and/or retrieval. | Sufficient to understand specific handling procedures for the specific detectors deployed, including documentation requirements. | - 2.1.2 Devices used in compliance with manufacturer’s instructions  
- 7.4.1 Start and stop dates and times of the measurement-exposure period  
- 7.4.2 Identification/serial numbers of detectors |
| Section 2.2 Responsible care for managing "Notifications" and noninterference agreements. | Sufficient, as applicable for the assigned task, to meet the intent and needs illustrated in Exhibits 5, 6, 7, 8 and/or 9 as employed or modified by the Qualified Measurement Professional. | - 4.0 Detector deployment periods that comply with the chosen testing strategy  
- 6.1 Testing that meets Closed-building Protocols  
- 7.1.8 Discussions that inform of federal or state guidance.  
- 7.5 Documentation on whether the responsible individual signed the noninterference agreement |
| Section 3 Identifying dwellings or units to be tested in accordance with Section 3.1 through 3.4 "Where to Test". | Sufficient clarity on specified units designated for testing, documentation needs, and an understanding of when to seek guidance if an unanticipated unit or building condition is encountered. | - 7.4.3 Locations tested  
- 7.4.3.1 Locations not tested, with explanation of the reasons why tests were not conducted or missing, lost and non-retrievable detectors |
| Section 4.4.1 Identifying basic, Group 1 heating and cooling systems (Exhibit 1) | Sufficient to trigger a request for guidance if unanticipated systems are encountered. | If appropriate, properly conducted testing for:  
- 4.4.2: Group 2 Multi-Zone HVAC  
- 4.4.3 Group 3a Variable Distribution Systems  
- 4.4.4 Group 3 Variable Distribution and/or Variable Ventilation HVAC Systems |
| Section 3.6 Identifying appropriate test locations within a room. | Sufficient to understand and conduct actions in accordance with Table 3.6. | - Tests conducted in accordance with Table 3.8 "Choosing a location in a room" |
| Section 5.0 "Quality Assurance" measurements. | Sufficient to integrate duplicate and blank measurement detectors, as instructed. | - 7.3.1 QC measurements conducted and reported as required |
| Section 7.6 “Report Protocol Deviations” and Section 7.7 "Report Temporary Conditions" | Sufficient to document observed deviations from Protocol Conditions (Section 7.6) | - Non-compliance with closed-building or normal occupied temperature.  
- Changes in the detector’s placement, whether any seal has been altered or test interfered with. |
|                                                                       | Sufficient to document Temporary Conditions (Section 7.7)                                                            | - Units that were vacant  
- Temporary radon mitigation methods  
- Condition of any permanent vents (i.e. open/closed) such as crawlspace vents |
CG SECTION 5
RADON DECAY PRODUCT MEASUREMENT

CG 5.1 Introduction
The unit of measurement provided by devices that measure radon decay products (RDPs) is Working Level (WL). The devices measure the activities of short-lived radioactive elements that result from the radioactive decay of radon gas. Often termed “radon progeny”, these decay product atoms are solid elements rather than gaseous and are left suspended in the air we breathe as radon gas decays.

It is the total Alpha energy from the short-lived decay products of radon (Po-218 and Po-214) that is measured when conducting radon decay product measurements.

Historically, action levels have been cited at 0.020 WL in the United States. The 0.020 WL is mathematically determined based upon an assumption that, when considering a national residential average, about 50% of the radon decay products remain suspended in the air and available for inhalation. More recently, some publications and authorities have indicated that 40% may be a more correct assumption.

CG 5.2 RDP Measurements:
While assumed equilibrium factors of 50% or 40% may be reasonable for national risk calculations, the normal operating parameters for each home, building or room can cause significant deviations compared to an assumed equilibrium factor. It is important for the measurement professional to understand and identify the presence of those parameters that can either increase or decrease the suspended radon decay products to determine if those effects are temporary or long-term, either of which can affect an interpretation of the results.

- One benefit for obtaining an RDP measurement is to identify situations where ventilation or other conditions have resulted in higher percentages of radon decay products suspended in the air compared to traditional assumptions. This situation would result in greater risk than indicated by a radon gas measurement.
- Another benefit for obtaining an RDP measurement is to identify situations where conditions cause lower percentages of radon decay products suspended in the air compared to traditional assumptions. If it can be verified that conditions that cause equilibrium factors to be lower than traditionally assumed are reliably stable, the risk may be lower than indicated by a radon gas measurement.

Regardless, the RDP measurement alone cannot pinpoint the equilibrium factor that existed during a test. Therefore, it alone cannot corroborate observations related to building systems or environmental conditions that may or may not be the normal, reliably stable condition. However, by simultaneously conducting a measurement of both radon gas and radon decay products, the measurement professional can better gauge the stability of conditions that may affect an occupant’s risk.

CG 5.3 Factors Influencing Equilibrium Factors
The following table provides examples of operating parameters that can increase or decrease the equilibrium factor (EF). This list is not fully comprehensive and the radon professional conducting RDP measurements should view any situation with the following two rules of thumb:

1) During situations where air circulation is high, more decay products will attach to physical surfaces rather than remain suspended in the air and hence the EF will decrease. Conversely low air circulation will cause an increase in EF.

2) Anything that will serve to increase concentrations of other indoor particles to which RDPs can attach before they contact physical surfaces will increase the suspended RDPs and hence the equilibrium factor. Conversely, where the air is very clean, fewer RDPs will attach to suspended particles (with more plating out on physical surfaces) causing the suspended RDPs and the EF to decrease.

---

## CG Table 5.3  
Factors that can Impact Equilibrium Factors (Percent of RDPs Suspended)

The below listing of effects is not exhaustive, but rather illustrative of the effects that these can have on the equilibrium factor. The radon professional should review the circumstances in each house that may be increasing or decreasing radon decay products to determine if those variables are long-term or intermittent in making recommendations to the client.

<table>
<thead>
<tr>
<th>Item</th>
<th>Effect on EF</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent Fan Activity such as Ceiling Fans</td>
<td>Decrease</td>
<td>Ceiling fans are intermittent in use. Low EF as a result of ceiling fan or other intermittently active fans will not likely be representative of other rooms without fans or EF during months without fan activity.</td>
</tr>
<tr>
<td>Window Air Conditioner</td>
<td>Decrease</td>
<td>Although window A/C should be in total recycle mode for any test, the air movement when operating can increase plate-out on physical surfaces.</td>
</tr>
<tr>
<td>Wall mounted split air conditioner or heat pump with blower</td>
<td>Decrease</td>
<td>Recirculated air from a wall unit can increase plate-out of RDPs to physical surfaces for the room in which it is located. A test in such a room may not be representative of other rooms, unless wall units are located in all occupied rooms.</td>
</tr>
<tr>
<td>Portable Circulating Fan</td>
<td>Decrease</td>
<td>The operation of a portable fan in a given room can increase plate-out within that room which would not be representative of other rooms in the building.</td>
</tr>
<tr>
<td>Forced Air Unit (Auto)</td>
<td>Decrease when blower is ON</td>
<td>Blowers of FAUs cause more plate-out when system is calling for heating or cooling. The amount of reduction is dependent upon frequency of use.</td>
</tr>
<tr>
<td>Forced Air (Constant ON)</td>
<td>Decrease</td>
<td>Increased air circulation will cause more RDPs to attach to physical surfaces. This is true for homes as well as commercial buildings. Note that energy management systems for large buildings may shut off blowers during unoccupied periods and cause EF to increase during those periods.</td>
</tr>
<tr>
<td>Modular air cleaners (Stand alone)</td>
<td>Decrease in room it is located within</td>
<td>Air cleaners can significantly reduce EF due to: (1) increased air movement and (2) removal of other suspended particles to which RDPs are attached. Low EFs in a room with an air cleaner will not be representative of other rooms in building.</td>
</tr>
<tr>
<td>Whole Building or Zoned Air Cleaners</td>
<td>Decrease</td>
<td>Whole house air cleaners can be stand-alone with their own ductwork system or incorporated into a forced air heating/cooling system with the blower running constantly at a low speed for air borne particulate and allergen removal.</td>
</tr>
<tr>
<td>Vacant Building</td>
<td>Variable</td>
<td>The absence of furniture in a building can decrease surfaces to which RDPs can attach. Conversely the absence of occupants can reduce use of air handling equipment.</td>
</tr>
<tr>
<td>Non-Forced-Air heating system</td>
<td>Increase</td>
<td>Buildings with radiant style heating systems have lower air movement and hence lower attachment of RDPs to physical surfaces.</td>
</tr>
<tr>
<td>Intermittent Particulate Releases</td>
<td>Increases</td>
<td>Activities that release particles into the air can increase EF during periods of release. Examples:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Smoking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vacuuming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Burning candles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use of fireplace or unvented combustion appliances</td>
</tr>
<tr>
<td>Longer-Term Particulates</td>
<td>Increase</td>
<td>High particulate levels in outdoor air can increase indoor particulate levels. Examples:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Smoke from fires in area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tested building in regions of high smog and elevated PM-2.5 plus levels</td>
</tr>
<tr>
<td>Clean outdoor air</td>
<td>Decrease</td>
<td>Areas where smog and outdoor particulate levels are very low, such as non-industrialized coastal areas can have low EF.</td>
</tr>
<tr>
<td>High Humidity</td>
<td>Increase</td>
<td>High humidity can provide airborne water droplets to which RDPs can attach (similar to dust particles). Attachment to water vapor can also neutralize charge of RDPs causing them to be less likely to plate out on physical surfaces.</td>
</tr>
<tr>
<td>Test device near charged surfaces</td>
<td>Decrease</td>
<td>Charged surfaces such as CRT monitors and TV screens that create localized static charges can attract RDPs near them.</td>
</tr>
</tbody>
</table>
# CG SECTION 6

## CLIMATE MAPS—AVERAGE OPERATING CONDITIONS FOR A BUILDING

### TEMPERATURE ZONES

<table>
<thead>
<tr>
<th>Climate Zone Designations</th>
<th>North American States or Cities</th>
<th>Annual Average Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Very Hot</td>
<td>Southern Florida and Hawaii</td>
<td>Miami 76°F</td>
</tr>
<tr>
<td>2 Hot</td>
<td>Florida, New Orleans, Houston, Mexico</td>
<td>New Orleans 68°F</td>
</tr>
<tr>
<td>3 Warm</td>
<td>North Carolina to Southern California</td>
<td>Atlanta 61°F</td>
</tr>
<tr>
<td>4 Mixed</td>
<td>NYC, PA, NJ, VA, KT, TN KS, MO, Seattle WA, and Portland OR.</td>
<td>Kansas City 54°F</td>
</tr>
<tr>
<td>5 Cool</td>
<td>MA, NY, OH, MI, IN, IL, IA, NE, CO, UT and NV.</td>
<td>Chicago 49°F</td>
</tr>
<tr>
<td>6 Cold</td>
<td>ME, NH, VT, WI, MN, ND, WY, SD and ND.</td>
<td>Montreal 43°F</td>
</tr>
<tr>
<td>7 Very Cold</td>
<td>Minot, ND; Anchorage, AK; Winnipeg, Canada</td>
<td>Winnipeg 36°F</td>
</tr>
<tr>
<td>8 Subarctic</td>
<td>Fairbanks Alaska; Cambridge Bay, Canada</td>
<td>Fairbanks 27°F</td>
</tr>
</tbody>
</table>
### Subarctic Climate Zone 8
Includes the utmost northern portions of North America.

**Fairbanks, Alaska (Annual avg. 27°F)**

<table>
<thead>
<tr>
<th>Monthly averages</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>25</td>
<td>4</td>
<td>-6</td>
<td>-8</td>
<td>-2</td>
<td>11</td>
<td>31</td>
<td>49</td>
<td>60</td>
<td>62</td>
<td>57</td>
</tr>
</tbody>
</table>

**Operating Condition Across The Year**
- Heating: 100%
- Intermittent activity: -
- Cooling: -

**Average Building Operating Condition**
- Heating active [e.g. outdoor temperature averages ≤ 65°F (18°C)]
- Clear characterization of radon hazard is most likely:
  - During the average condition (heating)

Additional Considerations: Preferred test periods are those that avoid extreme weather conditions [e.g. when outdoor temperature averages are > 0°F (-18°C)]

### Very Cold Climate Zone 7
Includes portions of many Canadian provinces and utmost northern locations in the United States.

**Minot, ND (Annual avg. 39°F)**

<table>
<thead>
<tr>
<th>Monthly averages</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56</td>
<td>45</td>
<td>26</td>
<td>14</td>
<td>6</td>
<td>11</td>
<td>21</td>
<td>41</td>
<td>53</td>
<td>61</td>
<td>68</td>
<td>67</td>
</tr>
</tbody>
</table>

**Operating Condition Across The Year**
- Heating: 83%
- Intermittent activity: 16%
- Cooling: -

**Average Building Operating Condition**
- Heating active [e.g. outdoor temperature averages ≤ 65°F (18°C)]
- Clear characterization of radon hazard is most likely:
  - During the average condition (≤ 65°F (18°C))

### Cold Climate Zone 6
Includes portions of ME, NH, VT, WI, MN, ND, WY, SD, ND and Canada.

**Minneapolis, MN (Annual avg. 45°F)**

<table>
<thead>
<tr>
<th>Monthly averages</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>61</td>
<td>50</td>
<td>33</td>
<td>19</td>
<td>13</td>
<td>18</td>
<td>31</td>
<td>46</td>
<td>59</td>
<td>68</td>
<td>73</td>
<td>71</td>
</tr>
</tbody>
</table>

**Operating Condition Across The Year**
- Heating: 75%
- Intermittent activity: 25%
- Cooling: -

**Average Building Operating Condition**
- Heating active [e.g. outdoor temperature averages < 65°F (18°C)]
- Clear characterization of radon hazard is most likely:
  - During the average condition (≤ 65°F (18°C))

### Cool Climate Zone 5
Includes portions of MA, NY, OH, MI, IN, IL, IA, NE, CO, UT and NV.

**Chicago, IL (Annual avg. 49°F)**

<table>
<thead>
<tr>
<th>Monthly averages</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65</td>
<td>53</td>
<td>40</td>
<td>27</td>
<td>22</td>
<td>26</td>
<td>37</td>
<td>49</td>
<td>59</td>
<td>69</td>
<td>74</td>
<td>72</td>
</tr>
</tbody>
</table>

**Operating Condition Across The Year**
- Heating: 75%
- Intermittent activity: 25%
- Cooling: -

**Average Building Operating Condition**
- Heating active [e.g. outdoor temperature averages ≤ 65°F (18°C)]
- Clear characterization of radon hazard is most likely:
  - During the average condition (≤ 65°F (18°C))
EXAMPLES FOR EACH OF THE EIGHT CLIMATE ZONES

**Mixed Climate Zone 4**
Includes portions of NY, NJ, PA, VA, KY, TN, KS, MO, WA, OR.

![Philadelphia, PA (Annual avg. 55° F)](image)

- **Operating Condition Across The Year**
  - Heating: 65%
  - Intermittent activity: 16%
  - Cooling: 16%

- **Average Building Operating Condition**
  - Heating active [e.g. outdoor temperature averages ≤ 65° F (18°C)]

- Clear characterization of radon hazard is most likely:
  - During the average condition (≤ 65° F (18°C))

**Warm Climate Zone 3**
Includes portions of various states ranging from North Carolina to Southern California.

![Atlanta, GA (Annual avg. 62° F)](image)

- **Operating Condition Across The Year**
  - Heating: 58%
  - Intermittent activity: 16%
  - Cooling: 25%

- **Average Building Operating Condition**
  - Heating active [e.g. outdoor temperature averages ≤ 65° F (18°C)]

- Clear characterization of radon hazard is most likely:
  - During the average condition (≤ 65° F (18°C))

**Hot Climate Zone 2**
Includes portions of FL, LA, TX, AZ and many southern portions of North America.

![New Orleans, LA (Annual avg. 69° F)](image)

- **Operating Condition Across The Year**
  - Heating: 42%
  - Intermittent activity: 16%
  - Cooling: 42%

- **Average Building Operating Condition**
  - Virtually equal portions of the year for heating or cooling.

- Clear characterization of radon hazard is most likely:
  - Heating active [e.g. outdoor temperature averages ≤ 65° F (18°C)]
  - Additional Considerations: Consider additional testing to evenly account for each condition.

**Very Hot Climate Zone 1**
Certain tropical areas (e.g., Southern Florida and Hawaii).

![Miami, FL (Annual avg. 76° F)](image)

- **Operating Condition Across The Year**
  - Heating: 50%
  - Intermittent activity: 50%

- **Average Building Operating Condition**
  - Virtually equal cooling and intermittent activity.

- Clear characterization of radon hazard is most likely:
  - 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.

  - Additional Considerations: Consider additional testing to evenly account for each condition.
Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily Buildings

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