ANSI/AARST **MAMF-2017**

An American National Standard

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

AARST CONSORTIUM ON NATIONAL RADON STANDARDS
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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.[3] 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 accredited 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.**

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[1] World Health Organization, "WHO Handbook on Indoor Radon: A Public Health Perspective" 2009

[2] Swedish Radiation Protection Authority, "Radon in Estonia Dwellings, Stockholm" 2003; and Valmari, T, Arvela, T and Reisbacka, "Radon in Finnish Apartment Buildings, Radiation Protection Dosimetry" 2012

[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/m^3 rather than literal conversion to 148 Bq/m^3) for locations where the International System of Units (SI) are used.

Normative Reference:

- EPA Guidance on Quality Assurance (402-R-95-012, October 1997) *See:* **www.epa.gov/radon/publications-about-radon**

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.

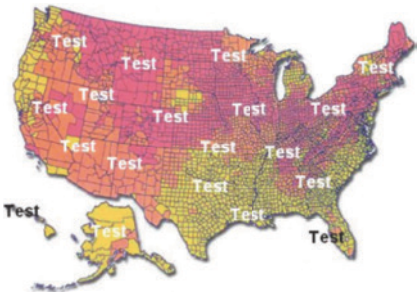
Not everyone who breathes radon decay products will develop lung cancer. An individual's risk of getting lung cancer from radon depends mostly on three factors: the concentration of radon, the duration of exposure and the individual's smoking habits. In addition, some people are more susceptible to lung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

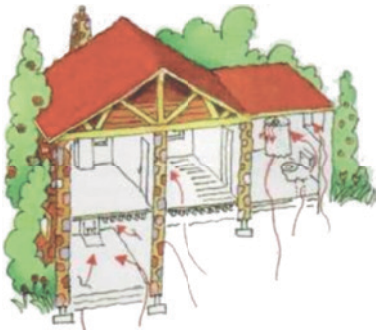
Because many people spend much of their time at home, the home is likely to be the most significant source of radon exposure. According to EPA, nearly 1 out of every 15 homes in the United States is estimated to have radon concentrations that exceed the EPA action level.

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**
- State radon offices: **http://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information - stateradon**
- Indian Nation radon offices: **www.epa.gov/epahome/tribal.htm**
- Regional EPA offices: **www.epa.gov/epahome/locate2.htm**
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: **www.nrsb.org**
- The AARST National Radon Proficiency Program (AARST-NRPP): **aarst-nrpp.com**

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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. [4]

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/m^3) 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**.)

[4] As point of reference, see the International Building Code (IBC) Section 310 for Residential Group R2 (as published by the International Code Council).