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An American National Standard

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

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MALB

Protocol for Conducting Measurements of Radon and Radon Decay Products In Schools and Large Buildings

Scope Summary and Introduction

This standard specifies procedures, minimum requirements and general guidance for measurement of radon and radon decay product concentrations in schools and large buildings.

THIS DOCUMENT INCLUDES:

I. Informational: Introduction to Radon

II. Informational: Guidance for Building Managers

III. Protocol for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings

The protocol includes instructions on where to test, strategies for conducting reliable tests, reporting and associated quality control measures.

Significance of Purpose

Radon is the leading cause of lung cancer among nonsmokers and the second leading cause of lung cancer in the general population.[1] For most school children and staff, the second largest contributor to their radon exposure is likely to be their school.[2] Thousands of classrooms nationwide have elevated radon levels, needlessly exposing hundreds of thousands of students and staff to this serious health risk.[3] With similar implications, a correlation has been observed between radon levels in homes, and workplaces in the same area.[4]

Radon in U.S. homes causes approximately 21,000 U.S. lung cancer deaths each year.[5] Whether at home, work or school, an individual's exposure to radon gas combines over time to increase the risk of preventable lung cancer.

This document contains minimum requirements and guidance designed to respond to the health threat in schools and large buildings.

Significance of Use

These protocols are intended to guide citizens, radon measurement professionals, property owners, facility managers, building occupants, consultants, regulators, radiation control programs, radon mitigation professionals and anyone concerned with radon measurement in schools and large buildings.

Applicability: The practices in this standard can be adopted as requirements for contractual relationships or as recommendations or requirements of a state, country, private proficiency program or other jurisdiction of authority. AARST recommends that any authority or jurisdiction 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 offers the Consortium on National Radon Standards an opportunity to update this document if appropriate.

Historical Perspective

In the 1950s, studies confirmed increased incidence of radon-induced lung cancer for workers in underground mines.

In 1970, OSHA promulgated a standard for occupational exposure limits to airborne radioactive materials that is currently designated as 29 CFR 1910.1096.

In the 1980s, studies found that exposure to radon in homes can exceed exposures found in studies of mine workers.

In 1988, the Indoor Radon Abatement Act authorized U.S. state and federal activities to reduce citizen risk of lung cancer caused by indoor radon concentrations.

Since the early 1990s, USEPA has advised all U.S. schools to test for radon and to reduce levels to below 4 pCi/L[2].

In 1999, with publication of BEIR VI[5], the National Academy of Sciences confirmed that any exposure to radon poses a degree of risk. 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 concentrations found in residential buildings.[1]

Initiated in 2010, the U.S. *Federal Radon Action Plan* highlights an *ultimate* public health goal of eliminating preventable radon-induced cancer. This plan is the result of a collaborative effort led by the U.S. Environmental Protection Agency (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).

Document History

The EPA developed informational guidance and recommended practices for measuring radon in schools with its July 1993 publication of *Radon Measurement in Schools* (EPA 402-R-92-014). Related guidance was published in the EPA documents *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 402-R-92-004, July 1992) and *Protocols for Radon and Radon Decay Product*

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

2 USEPA, "Radon Measurement In Schools", July 1993 (EPA-402-R-92-014)

3 USEPA, "Tools For Schools", June 2010"

4 Silvia Bucci, Gabriele Pratesi, Maria Letizia Viti, Marta Pantani, Francesco Bochicchio and Gennaro Venoso, "Radon in Workplaces: First results of an extensive survey and comparison with radon in homes", 2011

5 National Academy of Sciences, "Biological Effects of Ionizing Radiation" (BEIR VI Report) 1999

Measurements in Homes (EPA 402-R-92-003, May 1993). This standard seeks to harmonize the best practices from those documents with additional experience in technical needs for achieving reliable measurements in schools and large buildings.

Keywords

Radon Gas, Radon Test, Schools, Radon Measurement, Radon Decay Products, Radon Testing, Radon

Normative References

- *EPA Guidance on Quality Assurance* (402-R-95-012, October 1997)
- *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 402-R-92-004, July 1992)

For USEPA documents see:
http://www.epa.gov/radon/pubs

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 for locations where the International System of Units (SI) is used in standard practice (i.e. 4.0 pCi/L rounded to 150 Bq/m^3 rather than literal conversion to 148 Bq/m^3). Conversions should apply as commonly used in such locations or jurisdictions.

Consensus Process

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

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**

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 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.

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Designation: MALB
(Measurement of Air in Large Buildings)

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Informational
Introduction to Radon

Informational

A. Radon Facts

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

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

B. Radon's Health Effects

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

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

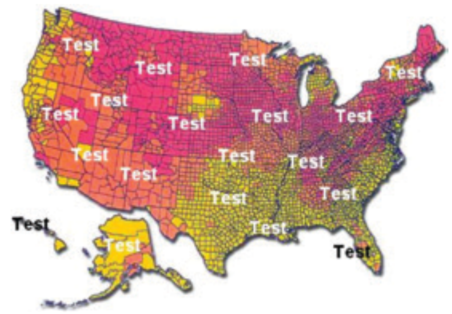
Risk increases as an individual is exposed to higher concentrations of radon over a longer period of time. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than it is for nonsmokers.

C. Radon Exposure

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

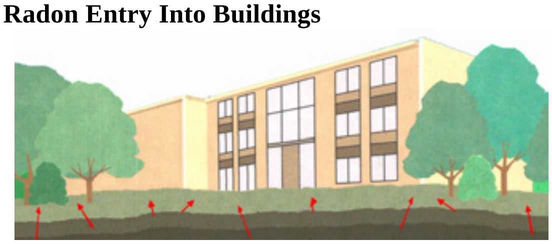
Elevated concentrations of radon have been found in homes and other buildings in every U.S. state and similarly throughout the world. According to EPA studies, nearly one out of every five schools in the United States are estimated to have radon concentrations that exceed the EPA action level in at least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

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



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

D. Radon Entry Into Buildings



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

Radon gas may also enter buildings in well water. Radon from well water used in a building can off-gas and raise concentrations in the air within the building. For buildings or small communities that use well water, a test of the water for radon should be considered, especially if the building is vacant or there is no water use when testing for radon in air. Radon in water testing is covered in a separate document and is beyond the scope of this testing protocol. More information on radon in drinking water is available at state radon offices, local drinking water safety programs or at federal water safety programs (e.g., EPA's Drinking Water Hotline (800) 426-4791

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

Factors Influencing Radon Entry

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

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

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

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

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

Heating, cooling and ventilation systems:

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

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

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

E. Contacts for Additional Information

In the United States:

- EPA website **http://www.epa.gov/radon**
- State radon offices: **http://www.epa.gov/iaq/whereyoulive.html**
- Indian Nation radon offices: **http://www.epa.gov/epahome/tribal.htm**
- Regional EPA offices: **http://www2.epa.gov/aboutepa/visiting-regional-office**
- The National Radon Proficiency Program (NRPP): **www.nrpp.info**
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: **www.nrsb.org**

In Canada:

- Health Canada **http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/radon-eng.php**
- The Canadian National Radon Proficiency Program (C-NRPP): **www.nrpp.info/cnrpp.shtml**

Informational
Guidance For Building Managers

This section contains no protocol requirements.

For the testing protocol, see Section III.

A. Introduction and Planning

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

Planning

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

Use a professional who has demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon measurement in schools and large buildings:

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

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

If considering using existing staff personnel to design and implement the radon testing program, training to ensure the quality of their work and demonstration of their proficiency by means of a license or certification is required by some jurisdictions. Obtaining national or local certification of personnel prior to testing should be considered a minimum requirement.

Preparation

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

- Become familiar with testing methods;
- Consult with a radon professional to determine an appropriate and practical testing strategy that meets the requirements of this standard's protocols as defined in Section **III**;
- Gather building information, drawings and history pertinent to the design of a radon testing plan. See Section III, subsection **2.2** for detailed information needed;
- Become familiar with building conditions required to conduct reliable radon tests. See Section **III**, subsection **2.3** for detailed information;
- 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;
- Investigate whether any previous tests have been conducted and collect any available test results;
- Design, implement and document a plan for communicating information about radon testing activities; and
- Become familiar with radon reduction recommendations (see Sections **H** and Section III, subsection **7.0**).

B. 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, health and safety staff, appropriate communications staff, maintenance staff, and a radon measurement professional when developing the communication plan. (See Exhibit **3**.) This plan should be agreed to and signed by the responsible parties.

Prior to the test:

- Develop notices (with general information, instructions, and who to contact for inquiries) that can be made specific for each affected audience, including:
  - Facilitating staff.

    These are people responsible for oversight of test devices and building conditions during the testing period such as building managers, maintenance managers, teachers and other supervisors.
  - Occupants such as students and workers.
  - Guardians of students or other occupants under supervised care.
- Develop timetables and methods for distribution of notices.
- Specify the staff member responsible for onsite activities.
- Specify additional communication paths between senior staff, facilitating staff, maintenance staff and the professional radon service provider.
- Specify the procedure for internal distribution of radon test data including:
  - Who is designated to receive data or reports from the radon measurement professional.
  - What situations, if any, warrant reporting interim and incomplete test results prior to completion of all test phases. See Section III, subsections **2.7**, **4.5** and **4.6** for topics that