

# **Housing Authority of the City and County of Denver**

1035 Osage Street, Denver, Colorado 80204

## **Standard Operating Procedures**

### **Radon Testing and Mitigation**

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## **1. Purpose**

The Standard Operating Procedures (“SOP”) for radon testing and mitigation provides a responsible plan to minimize exposure of building occupants, maintenance workers, and office personnel to radon by establishing work practices and procedures. This document outlines and describes the most current recommendations for radon testing and mitigation. This document does not address real estate transactions and is not meant to be technically exhaustive but rather a guideline for the Housing Authority of the City and County of Denver (“DHA”) building and maintenance managers to address radon testing and mitigation throughout each residential development.

It is DHA’s intent to perform radon testing throughout each residential development, maintain radon test results for each unit tested and retest according to this SOP. If mitigation is warranted DHA will develop a mitigation strategy utilizing qualified mitigation professionals, mitigate and perform required maintenance of each radon mitigation system installed. DHA will facilitate radon training for field staff.

## **2. Introduction to Radon**

Radon is a naturally occurring colorless, odorless gas that is a by-product of the radioactive decay of uranium potentially present in the bedrock and soil throughout the United States. 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 joint between walls and floors, porous concrete block walls, open sump pits, crawlspaces and openings around utility penetrations and heating, ventilation and air conditioning (“HVAC”) ducts.

Eventually, radon in soil gas enter the pathways of the home, decays into radioactive particles or decay products that become trapped in your lungs when you inhale. As these particles decay and release small bursts of radiation, the lung tissue can become damaged and can lead to lung cancer over the course of a lifetime. The Environmental Protection Agency (EPA) guidance action level for annual exposure to radon is 4.0 picocuries per Liter of air (pCi/L) for all frequently occupied rooms of a building.

Radon is a known human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. 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. The risk of developing lung cancer depends mainly on three factors: the concentration of radon, the duration of exposure and the individual’s smoking habits.

The EPA Map of Radon Zones was developed to identify areas of the United States with the potential for elevated indoor air levels. Most of Colorado including Denver is included within Zone 1, meaning Denver has predicted average indoor radon screening levels greater than 4 pCi/L. The Colorado Department of Public Health and Environment (CDPHE) Radon Zone Map for Colorado indicates all 64 counties are in Zone 1. It is estimated over 50% of homes in Colorado have elevated radon levels.

### **3. Radon Guidelines**

This SOP was developed in general accordance with The American Association of Radon Scientist and Technologists (“AARST”) *Radon and Radon Decay Product Measurements in Multifamily Buildings, MAMF-2017* and the AARST Radon Mitigation Standards for Multifamily Buildings (RMS-MF 2018), which includes the best practices from the below referenced EPA documents. Appendix A provides a copy of the EPA’s *A Citizen’s Guide to Radon* (EPA 402-K-07-009).

The below guidance documents were utilized to develop this SOP.

- EPA A Citizen’s Guide to Radon (EPA 402-K-07-009) (Appendix A).
- EPA Protocols for Radon and Radon Decay Product Measurements in Homes (EPA 402-R-93-003).
- EPA Indoor Radon and Radon Decay Product Measurement Device Protocols (EPA 402-R-92-004).
- EPA Home Buyer’s and Seller’s Guide to Radon (EPA 402-K-06-093).
- AARST Protocols for Measuring Radon and Radon Decay Products in Multifamily Buildings (MAMF-2017).
- AARST Radon Mitigation Standards for Multifamily Buildings (RMS-MF 2018).
- Colorado Department of Public Health and Environment (“CDPHE”) Measuring and Mitigating Radon in Colorado, Dated May 1, 2018.

### **4. Radon Testing**

Initial or screening measurement will be performed for existing DHA residential homes, developments and recently completed new construction projects. A measurement will be collected in each ground contact apartment, dwelling and those rooms that are used for office space. This includes units over crawlspaces, utility tunnels or parking garages.

All individuals conducting radon measurement activities in multifamily buildings shall be qualified for their appropriate task. For the purpose of 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 and retrieve and to design, plan, and implement quality procedures when conducting radon measurements in multifamily buildings as established in certification requirements of the National Radon Proficiency Program (“NRPP”) or the National Radon Safety Board (“NRSB”).

#### **4.1 Where to Test Inside a Building**

Testing within each dwelling will be performed 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 being used but could serve as a den, playroom, office, work area or an additional bedroom sometime in the future, conduct a test in this level.

Conduct a measurement in non-residential ground-contact rooms or areas such as utility rooms, storage rooms, and maintenance rooms that are occupied with little or no modification or have air communication with occupied areas such as elevator shafts or stairwells. For larger rooms, one detector will be placed for every 2,000 square feet.

On upper floors, conduct a measurement in at least one apartment on each floor to 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.

#### **4.2 Short Term Radon Testing**

Air Chek or equivalent activated charcoal short-term radon test kits or similar test kit will be used to perform the initial short-term radon measurement at each residential unit. Typically, the kits are placed within the residential unit for two (2) days. Test all areas during the same time period. Short-term tests lasting less than four (4) days should not be conducted during unusually severe storms or periods of unusually high winds. Test periods of at least 4-5 days are recommended for multifamily buildings because it is sometimes difficult to ensure closed building conditions existed twelve (12) hours prior to the test at every dwelling.

#### **4.3 Closed Building Conditions**

Short-term radon testing requires closed building conditions to stabilize the radon concentration and entry rates and increase the reproducibility of the measurement. Without closed building conditions, measurements can indicate higher or lower readings than are typically present. Choosing a time of year when required closed building conditions are a normal condition will aid in ensuring reliable measurements. **Appendix B** contains an example tenant notification for closed building conditions. Listed below are the closed building protocols.

- Closed building conditions shall be maintained during the test period and for twelve (12) hours prior to the initiation of measurements lasting less than four (4) days.
- All windows on all levels of the building shall be kept closed and all external doors shall be kept closed except for normal entry and exit.
- Heating and cooling systems shall be set at normal, occupied, operating temperatures. Fan control shall be set at intermittent activity unless the system is designed to only run the fan continuously.

- Whole house fans shall not be operated.
- Tenants should avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air into and out of the dwelling.
- Window air conditioning units shall only be operated in a re-circulating mode.
- Window fans shall be removed or sealed shut.
- Equipment that supplies fresh air to the dwelling shall be deactivated unless it is an integral part of the HVAC system or supplies make-up air to a combustion appliance.
- Fans installed in attics to control only attic air and not whole-building temperature or humidity may continue to operate.
- Air exchangers: Normal operation of permanently installed ventilation systems such as energy recovery ventilators may continue during closed building conditions so long as the system is regularly maintained and continuously operational.

#### **4.4 Where to Place the Detector Inside the Unit**

The following criteria shall be used to select a location in a room to place a detector:

- Place the detectors within the general breathing zone.
- Locate detectors no less than three (3) feet from exterior doors and windows or other potential openings to the outdoors, one (1) foot from exterior wall of building, twenty (20) inches from the floor and four (4) inches from other detectors and surrounding objects.
- Detectors that will be suspended, an optimal height is no higher than eight (8) feet from the floor and a minimum of one (1) foot below the ceiling.
- Select a location where the detectors will not be disturbed during the measurement period. The detectors must not be moved, covered or have their performance altered during the test.
- Do not place detectors inside closets, crawlspaces or hallways or in enclosed areas of high humidity or high velocity. These areas may include kitchens, laundry rooms, and bathrooms.
- Do not place detectors in cabinets, sumps, or nooks within the building foundation.
- Do not place detectors near drafts caused by heating, ventilating and air conditioning vents, or fans.
- Do not place detectors near heat sources, such as on appliances, near fireplaces or in direct

sunlight.

- Avoid placing detectors on or near furnishings made or containing natural stone such as granite counters, hearths or slate pool tables.

#### **4.5 Testing New Construction**

Radon testing will be performed at DHA's new construction. Below is a list of building materials that shall be completed or installed prior to test initiation.

- Insulation
- Exterior doors and hardware
- Windows
- Heating and cooling units and set to run at normal occupancy
- Ceiling coverings
- Interior trim and wall covering
- Exterior siding, weatherproofing and caulking
- Structural openings to the exterior as a result of incomplete construction

#### **4.6 Interpreting Initial Short-Term Radon Results**

Based on EPA's "Citizen Guide to Radon" (Appendix A) if the first short-term test is more than twice the action level (8 pCi/L) conduct a second short-term immediately. If the initial short-term radon test is less than twice the action level (4 to 8 pCi/L) conduct either a short-term or long-term radon test.

Alpha track long-term radon detectors shall be deployed for a minimum of 91 days. It is recommended that the detectors are deployed for at least six (6) months over different seasons. Closed building conditions are not required but are recommended for long-term measurements. If the average of the two (2) short-term radon tests or the long-term test meets or exceeds the action level of 4 pCi/L DHA will take appropriate action.

Appropriate action could consist of the installation of an active sub-slab depressurization radon mitigation system, sealing cracks and other openings in the foundation, room pressurization to prevent radon from entering the building, increased air exchanges throughout the building and natural ventilation such as opening doors and windows.

Following the installation of the mitigation system a second short-term radon measurement will be collected to confirm the mitigation system is reducing radon concentrations within the dwelling. Prior to beginning a test, a permanently installed active radon reduction system shall have been operating for at least 24 hours and shall continue to operate during the test period. Closed building conditions will be required.

If the initial short-term radon test is less than the action level of 4 pCi/L, consider mitigating the building if test results indicate radon concentration greater than half the action level (between 2 to 4 pCi/L). Note that reducing and accurately confirming radon concentrations of about 2.0 pCi/L

or below may be difficult. Low results should be confirmed again during different seasons or using a long-term device. Retesting will be performed at least every five (5) years and whenever significant changes to the home's structure or mechanical systems occur.

#### **4.7 Quality Control and Quality Assurance**

Duplicate measurements will be collected at a rate of 10% of all test locations. Duplicates are checks to assess test result consistency (precision). Duplicates are hung side-by-side, 6-12 inches apart, for identical test periods. If the higher duplicate measurement result is twice or more than the lower result, a repeat test will be required.

Blank measurements will be no less than 5% of all testing locations. Blanks are quality control measurements made to assess contamination during storage.

Spike measurements, measurements of known radon environment made to assess bias will be collected for large multifamily buildings at a rate of no less than 3 per 100 measurement locations.

#### **4.8 Documentation**

The report containing test results shall contain sufficient information to allow DHA to evaluate the data, interpretations and also make comparisons to any previous or future tests. The final report at a minimum shall include the following information:

- Test site address including zip code.
- The company and measurement professional's name, contact information, and current certificate identification number.
- The name and identification number of the service or organization used to analyze detectors.
- A summary of measurement results and a statement outlining any recommendations concerning actions for retesting or mitigation.
- Detector locations including drawing.
- A description of any observed deviations from appropriate measurement procedures that may affect the measurement results, including closed building conditions, normal occupied temperature, changes in detector placement, and a description of unusual severe weather conditions.
- Mitigation system status.
- Any temporary building conditions.
- Statement of test limitations.



## **5. Radon Mitigation**

Appropriate action to address radon mitigation could consist of the installation of an active sub-slab depressurization radon mitigation system, sealing cracks and other openings in the foundation, room pressurization to prevent radon from entering the building, increased air exchanges throughout the building and natural ventilation such as opening doors and windows.

One mitigation strategy is to seal all openings, cracks, and crevices in the concrete foundation floor including the perimeter crack or expansion joint and walls with polyurethane caulk to prevent radon and other soil gases from entering the home. Whenever application of sealants, caulks, or bonding agents that warrant ventilation of work areas is anticipated, DHA will provide notice to occupants that include the following text:

Common construction sealants used to prevent radon entry at foundations and other locations will normally emit vapors that contain volatile organic compounds (“VOC”s). While these chemicals are commonly used, some individuals may experience discomfort or other health effects when exposed to such chemicals. Symptoms may include nausea, headaches, dizziness, drowsiness and/or an allergic reaction. Special consideration should be made for very young or elderly who cannot communicate symptoms experienced. If symptoms are observed leave the area immediately to breathe fresh air and avoid further exposure. If symptoms persist seek medical attention.

### **5.1 Mitigation Design**

When it is determined that an active sub-slab depressurization radon mitigation system will be utilized to reduce radon levels it will be designed and installed to avoid compromising the function of any mechanical system or ground water control system and to avoid obstructing doorways or windows and accessibility to switches, controls, electrical boxes or equipment requiring maintenance. The items listed below will be considered when designing the mitigation system.

- Review all available radon measurements for the building
- Known hazards such as utility lines on the property
- Foundation type
- HVAC
- Review construction design drawings including floor plans
- Review past and future renovation plans for structural design and HVAC.

A visual inspection shall be conducted to help identify any specific building characteristics, hazards, configurations that may affect the design, installation and effectiveness of a mitigation system, such as slab openings, crawlspaces, adjoining slabs, potential footing locations and soil gas migration pathways, identification of fire rated assemblies or separation barriers, location of

air intake openings and HVAC system.

If it is determined that a radon mitigation is needed the system will be designed and installed as a permanent addition to the building.

## **5.2 Mitigation OM&M Plan**

Following the installation of the appropriate mitigation system the contractor shall supply DHA with the essential tools for Client efforts in long-term risk management. The mitigation contractor shall provide DHA in writing, a final operations, maintenance and monitoring plan (“OM&M Plan”) for the mitigation system which will include the following:

- A recommendation to retest every two years.
- A description of the fan monitors and the recommendation to check the monitors at least quarterly.
- Document startup parameters such as pressure gauge readings that existed at the time mitigation was initially achieved.
- A list of actions for the Client to take if the fan monitor indicates system degradation or failure.
- A description of the mitigation systems as installed to include basic operating principles and system layout narrative or system components labeled on a floor plan and photographic documentation.
- A description of any important observations that might adversely affect the mitigation system or other building systems and any deviations from this standard or state requirement.
- A statement of limitations the contractor places on professional obligations, future maintenance and monitoring of the mitigation systems effectiveness.
- Contact information for service inquires and identification of the Qualified Mitigation Professional responsible for adherence to protocols to include, name, address, phone number, certificate number and signature.
- Historical information to include, pre and post mitigation test data, pre and post mitigation investigation summary, copies of contracts and warranties, any building permits required and an estimate of annual operating costs.

## **5.3 Owners OM&M Plan Responsibility**

Building and maintenance managers should be able to verify by documentation that the minimum requirements of an OM&M plan have been maintained. Essential requirements for long-term risk

management are satisfied when building owners and managers perform the following:

- Maintenance inspections as stipulated in the operational and maintenance plan for fan monitors, system components and any system controls to verify continued operation as designed.
- Maintain equipment, any annotation on equipment and any instructions. Engage a qualified professional to inspect components of the mitigation system every 2 years.
- Conduct a retest of mitigated areas at least every 2 years and retest all previously tested locations of the building up to the third-floor level at least every 5 years. In addition, retest when any of the following occur:
  - When a new addition is constructed, or significant renovations occur.
  - When heating or cooling systems are significantly altered resulting in changes to air pressure or distribution.
  - When ventilation is significantly altered by extensive weatherization or changes to the mechanical system.
  - When a significant opening to the soil occurs.
  - A mitigation system is altered, modified or repaired.
  - When a ground contact area has not been previously tested is occupied.
- Disclose the existence of the mitigation system and its purpose for protecting health and safety to current and future occupants or tenants.
- Disclose the OM&M plan and all known relevant history including this statement of inherent obligations to prospective purchasers of the property.

#### **5.4 New Construction Radon Mitigation**

DHA will also consider radon resistant construction techniques for new construction projects. The five (5) basic features that builders should include to prevent radon from entering the home are:

1. Use a 4” layer of clean, coarse gravel below the foundation. This layer of gravel allows the soil gases, which includes radon that occur naturally in the soil to move freely underneath the foundation. This is sometimes called the “air flow layer” or “gas permeable layer” because the loose gravel allows gases to circulate.
2. Place plastic sheeting or a vapor barrier on top of the gravel to prevent soil gases from entering the home.

3. Install a 3” to 4” solid PVC pipe vertically from the gravel layer through the houses conditioned space and roof to safely vent radon and other soil gases outside above the home or similar system.
4. Seal all openings, cracks, and crevices in the concrete foundation floor including the perimeter crack or expansion joint and walls with polyurethane caulk to prevent radon and other soil gases from entering the home.

Install an electrical junction box in the attic for use with an active radon mitigation system if needed.

The construction team shall include individuals who have the appropriate technical knowledge, skills and experience required to mitigate large buildings, including at least one “Qualified Mitigation Professional” defined as:

An individual who has demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon mitigation of large buildings as established in certification requirements of the NRPP or the NRSB.

The “Qualified Mitigation Professional” will participate in the design of mitigation systems, oversee the proper installation of the systems during construction and oversee testing and acceptance post construction.

## **6. Building Testing and Maintenance Protocols**

The purpose of testing is to identify locations throughout DHA’s residential properties that have elevated radon concentrations and to determine if radon mitigation is necessary to protect current and future occupants. The assigned Field Manager/Casualty Loss Specialist will oversee radon testing. The building manager will facilitate testing, including tenant notification, providing access to the buildings, and maintaining records.

The building manager will need to become familiar with testing methods, building conditions that are required to achieve reliable radon tests, investigate if previous tests were conducted and collect any available results and become familiar with guidance for when radon reduction is recommended.

The building manager will need to supply the testing company with building information including a building floor plan and a description of the different heating and cooling systems in the building. Additionally, the building manager will implement and document a plan for communicating information about radon testing activities within the building to tenants. Building managers will not make decisions on mitigation based on results, the “Qualified Measurement Professional” will make recommendation within the report whether or not mitigation is needed.

Radon measurements are a radiation exposure measurement. Because the effects of radiation

exposure may not become apparent until many years have passed, measurement data should be maintained permanently. The building manager will be responsible for ensuring that all records are filed for each of their tests and that duplicate records are sent to the DHA Central Office for maintenance there as well. These items include but are not limited to tenant notifications and the final report.

The building manager will also be responsible for transferring historical data and communicating mitigation system details to new building managers. For large residential developments records shall be maintained onsite. For individual homes or dispersed housing, the building manager will maintain records at a secure facility or office and transfer those records if there is a change in management.

The maintenance manager will also help facilitate testing and will be responsible for tenant notification including closed building condition requirements and unit access. In order to inform occupants of the dwelling about the test and the conditions of the test, a “Radon Survey in Progress” notification form with the conditions of the test stated on the notification, will be posted upon initiation of a short-term test in a conspicuous location of the dwelling by maintenance personnel.

If a building has a mitigation system, maintenance personnel shall check each mitigation system per the OM&M plan to ensure the proper operation or at a minimum quarterly. If the system is determined not to be working properly a qualified mitigation company will be contacted to repair the mitigation system.

## **6.1 Building and Maintenance Manager Responsibilities**

Building and maintenance managers should be able to verify by documentation that the minimum requirements of an OM&M plan have been maintained. Essential requirements for long-term risk management are satisfied when building owners and managers perform the following:

- Maintenance inspections as stipulated in the OM&M Plan or at least quarterly for fan monitors, system components and any system controls to verify continued operation as designed.
- Maintain equipment, any annotation on equipment and any instructions. Engage a qualified professional to inspect components of the mitigation system every 2 years.
- Conduct a retest of mitigated areas at least every 2 years and retest all previously tested locations of the building up to the third-floor level at least every 5 years. In addition, retest when any of the following occur:
  - When a new addition is constructed, or significant renovations occur.
  - When heating or cooling systems are significantly altered resulting in changes to air pressure or distribution.

- When ventilation is significantly altered by extensive weatherization or changes to the mechanical system.
- When a significant opening to the soil occurs.
- A mitigation system is altered, modified or repaired
- When a ground contact area has not been previously tested is occupied
- Disclose the existence of the mitigation system and its purpose for protecting health and safety to current and future occupants or tenants. Best practice includes a publicly observable notice
- Disclose the OM&M plan and all known relevant history including this statement of inherent obligations to prospective purchasers of the property

## **7. Radon Training and Education**

DHA building managers and maintenance personnel are encouraged to participate in online radon awareness training and become familiar with this radon SOP guidance document.

Building managers, maintenance staff and tenants that will require testing within their units will be supplied a copy of the EPA document, *“The Citizens Guide to Radon”*. Building managers and maintenance staff are expected to read and understand the EPA document and this SOP.

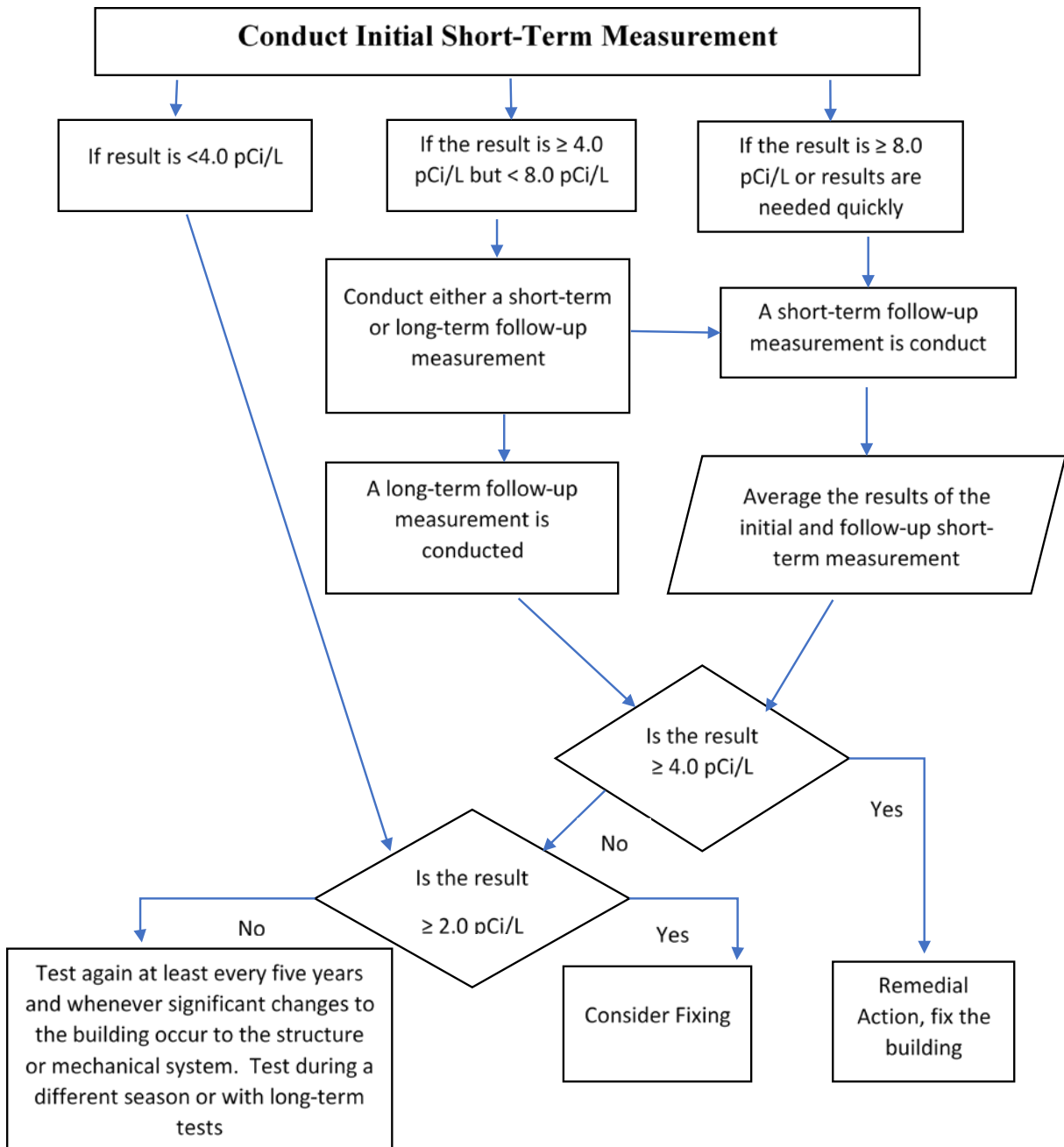
All individuals engaging in radon measurement activities in multifamily buildings shall be qualified for their appropriate task. For the purpose of testing protocol, a “Qualified Measurement Professional” is defined as:

An individual who has demonstrated a minimum degree of appropriate technical knowledge and skills sufficient both to place and retrieve and to design, plan, and implement quality procedures when conducting radon measurements in multifamily buildings as established in certification requirements of the NRPP or the NRSB.

An individual designing and installing mitigation systems shall be a “Qualified Mitigation Professional” defined as:

An individual who has demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon mitigation of large buildings as established in certification requirements of the NRPP or the NRSB.

## 8. Radon Flow Chart





# A Citizen's Guide to Radon

The Guide to Protecting  
Yourself and Your Family from  
Radon

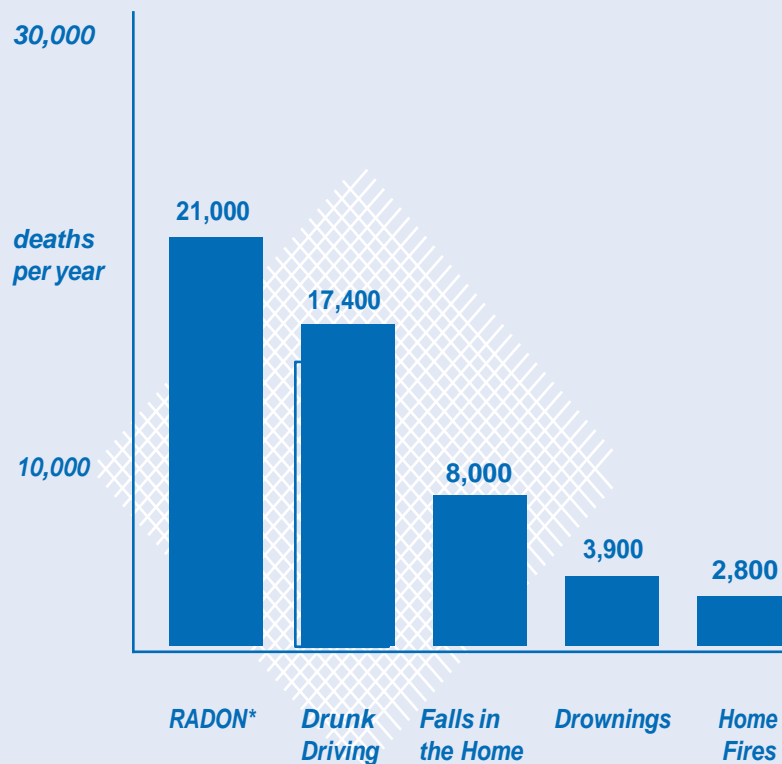




## EPA Recommends:

- ▼ **Test your home for radon—it's easy and inexpensive.**
- ▼ **Fix your home if your radon level is 4 picocuries per liter (pCi/L) or higher.**
- ▼ **Radon levels less than 4 pCi/L still pose a risk, and in many cases may be reduced.**

**Radon is estimated to cause thousands of lung cancer deaths in the U.S. each year.**



\*Radon is estimated to cause about 21,000 lung cancer deaths per year, according to EPA's 2003 Assessment of Risks from Radon in Homes (EPA 402-R-03-003). The numbers of deaths from other causes are taken from the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Report and 2002 National Safety Council Reports.

# OVERVIEW

## ***Radon is a cancer-causing, radioactive gas.***

You can't see radon. And you can't smell it or taste it. But it may be a problem in your home.

Radon is estimated to cause many thousands of deaths each year. That's because when you breathe air containing radon, you can get lung cancer. In fact, the Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today. Only smoking causes more lung cancer deaths. **If you smoke and your home has high radon levels, your risk of lung cancer is especially high.**

## ***Radon can be found all over the U.S.***

Radon comes from the natural (radioactive) breakdown of uranium in soil, rock and water and gets into the air you breathe. Radon can be found all over the U.S. It can get into any type of building—homes, offices, and schools—and result in a high indoor radon level. But you and your family are most likely to get your greatest exposure at home, where you spend most of your time.

## ***You should test for radon.***

Testing is the only way to know if you and your family are at risk from radon. EPA and the Surgeon General recommend testing all homes below the third floor for radon. EPA also recommends testing in schools.

Testing is inexpensive and easy—it should only take a few minutes of your time. Millions of Americans have already tested their homes for radon (see page 5).

## ***You can fix a radon problem.***

Radon reduction systems work and they are not too costly. Some radon reduction systems can reduce radon levels in your home by up to 99%. Even very high levels can be reduced to acceptable levels.

## ***New homes can be built with radon-resistant features.***

Radon-resistant construction techniques can be effective in preventing radon entry. When installed properly and completely, these simple and inexpensive techniques can help reduce indoor radon levels in homes. In addition, installing them at the time of construction makes it easier and less expensive to reduce radon levels further if these passive techniques don't reduce radon levels to below 4 pCi/L.

**Every new home should be tested after occupancy, even if it was built radon-resistant.** If radon levels are still in excess of 4 pCi/L, the passive system should be activated by having a qualified mitigator install a vent fan. For more explanation of radon resistant construction techniques, refer to EPA publication, *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes* (see page 15).

## HOW DOES RADON GET INTO YOUR HOME?

**Any home may have a radon problem.**

Radon is a radioactive gas. It comes from the natural decay of uranium that is found in nearly all soils. It typically moves up through the ground to the air above and into your home through cracks and other holes in the foundation. Your home traps radon inside, where it can build up. Any home may have a radon problem. This means new and old homes, well-sealed and drafty homes, and homes with or without basements.

Radon from soil gas is the main cause of radon problems. Sometimes radon enters the home through well water (see page 8). In a small number of homes, the building materials can give off radon, too. However, building

### **RADON GETS IN THROUGH:**

1. Cracks in solid floors.
2. Construction joints.
3. Cracks in walls.
4. Gaps in suspended floors.
5. Gaps around service pipes.
6. Cavities inside walls.
7. The water supply.



materials rarely cause radon problems by themselves.

Nearly 1 out of every 15 homes in the U.S. is estimated to have elevated radon levels. Elevated levels of radon gas have been found in homes in your state. Contact your state radon office (<https://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information>) for general information about radon in your area. While radon problems may be more common in some areas, any home may have a problem. The only way to know about your home is to test.

Radon can also be a problem in schools and workplaces. Ask your state radon office ([www.epa.gov/radon/wherelive.html](http://www.epa.gov/radon/wherelive.html)) about radon problems in schools, daycare and childcare facilities, and workplaces in your area (also visit <https://www.epa.gov/radon>).

# HOW TO TEST YOUR HOME

You can't see radon, but it's not hard to find out if you have a radon problem in your home. All you need to do is test for radon. Testing is easy and should only take a few minutes of your time.

The amount of radon in the air is measured in "picocuries per liter of air," or "pCi/L." There are many kinds of low-cost "do it yourself" radon test kits you can get through the mail and in some hardware stores and other retail outlets. If you prefer, or if you are buying or selling a home, you can hire a qualified tester to do the testing for you. You should first contact your state radon office about obtaining a list of qualified testers. You can also contact a private radon proficiency program for lists of privately certified radon professionals serving your area. For links and more information, visit <https://www.epa.gov/radon/find-radon-test-kit-or-measurement-and-mitigation-professional>.

## There are Two General Ways to Test for Radon:

### SHORT-TERM TESTING:

*The quickest way to test is with short-term tests. Short-term tests remain in your home for two days to 90 days, depending on the device. "Charcoal canisters," "alpha track," "electret ion chamber," "continuous monitors," and "charcoal liquid scintillation" detectors are most commonly used for short-term testing. Because radon levels tend to vary from day to day and season to season, a short-term test is less likely than a long-term test to tell you your year-round average radon level. If you need results quickly, however, a short-term test followed by a second short-term test may be used to decide whether to fix your home (see also page 7 under Home Sales).*

### LONG-TERM TESTING:

*Long-term tests remain in your home for more than 90 days. "Alpha track" and "electret" detectors are commonly used for this type of testing. A long-term test will give you a reading that is more likely to tell you your home's year-round average radon level than a short-term test.*

## How To Use a Test Kit:

Follow the instructions that come with your test kit. If you are doing a short-term test, close your windows and outside doors and keep them closed as much as possible during the test. Heating and air conditioning system fans that re-circulate air may be operated. Do not operate fans or other machines which bring in air from outside. Fans that are part of a radon-reduction system or small exhaust fans operating only for short periods of time may run during the test. If you are doing a short-term test lasting just 2 or 3 days, be sure to close your windows and outside doors at least 12 hours **before** beginning the test, too. You should not conduct

**Testing is easy  
and should only  
take a few  
minutes of  
your time.**

## HOW TO TEST YOUR HOME *continued*

short-term tests lasting just 2 or 3 days during unusually severe storms or periods of unusually high winds. The test kit should be placed in the lowest lived-in level of the home (for example, the basement if it is frequently used, otherwise the first floor). It should be put in a room that is used regularly (like a living room, playroom, den, or bedroom) but **not** your kitchen or bathroom. Place the kit at least 20 inches above the floor in a location where it won't be disturbed—away from drafts, high heat, high humidity, and exterior walls. Leave the kit in place for as long as the package says. Once you've finished the test, reseal the package and send it to the lab specified on the package right away for analysis. You should receive your test results within a few weeks.

### ***EPA Recommends the Following Testing Steps:***

**Step 1.** *Take a short-term test. If your result is 4 pCi/L or higher, take a follow-up test (Step 2) to be sure.*

**Step 2.** *Follow up with either a long-term test or a second short-term test:*

- *For a better understanding of your year-round average radon level, take a long-term test.*
- *If you need results quickly, take a second short-term test.*

*The higher your initial short-term test result, the more certain you can be that you should take a short-term rather than a long-term follow up test. If your first short-term test result is more than twice EPA's 4 pCi/L action level, you should take a second short-term test immediately.*

**Step 3.** • *If you followed up with a long-term test: Fix your home if your long-term test result is 4 pCi/L or more.*

- *If you followed up with a second short-term test: The higher your short-term results, the more certain you can be that you should fix your home. Consider fixing your home if the average of your first and second test is 4 pCi/L or higher (see also page 7 under Home Sales).*



# WHAT YOUR TEST RESULTS MEAN

The average indoor radon level is estimated to be about 1.3 pCi/L, and about 0.4 pCi/L of radon is normally found in the outside air. The U.S. Congress has set a long-term goal that indoor radon levels be no more than outdoor levels. While this goal is not yet technologically achievable in all cases, most homes today *can* be reduced to 2 pCi/L or below.

Sometimes short-term tests are less definitive about whether or not your home is above 4 pCi/L. This can happen when your results are close to 4 pCi/L. For example, if the average of your two short-term test results is 4.1 pCi/L, there is about a 50% chance that your year-round average is somewhat below 4 pCi/L. However, EPA believes that any radon exposure carries some risk—no level of radon is safe. Even radon levels below 4 pCi/L pose some risk, and you can reduce your risk of lung cancer by lowering your radon level.

If your living patterns change and you begin occupying a lower level of your home (such as a basement) you should retest your home on that level.

Even if your test result is below 4 pCi/L, you may want to test again sometime in the future.

**Test your home now and save your results. If you find high radon levels, fix your home before you decide to sell it.**

## RADON AND HOME SALES

*More and more, home buyers and renters are asking about radon levels before they buy or rent a home. Because real estate sales happen quickly, there is often little time to deal with radon and other issues. The best thing to do is to test for radon NOW and save the results in case the buyer is interested in them. Fix a problem if it exists so it won't complicate your home sale. If you are planning to move, review EPA's pamphlet "Home Buyer's and Seller's Guide to Radon," which addresses some common questions (<https://www.epa.gov/radon/home-buyers-and-sellers-guide-radon>). You can also use the results of two short-term tests done side-by-side (four inches apart) to decide whether to fix your home.*

*During home sales:*

- *Buyers often ask if a home has been tested, and if elevated levels were reduced.*
- *Buyers frequently want tests made by someone who is not involved in the home sale. Your state radon office (<https://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information>) can assist you in identifying a qualified tester.*
- *Buyers might want to know the radon levels in areas of the home (like a basement they plan to finish that the seller might not otherwise test.*

*Today many homes are built to help prevent radon from coming in. Building codes in your state or local area may require these radon-resistant construction features. If you are buying or renting a new home, ask the owner or builder if it has radon-resistant features. The EPA recommends building new homes with radon-resistant features in high radon potential (Zone 1) areas. Even if built radon-resistant, every new home should be tested for radon after occupancy. If you have a test result of 4 pCi/L or more, consult a qualified mitigator (<http://www.epa.gov/radon/find-radon-test-kit-or-measurement-and-mitigation-professional#who>) to estimate the cost of upgrading to an active system by adding a vent fan to reduce the radon level. In an existing home, the cost to install a radon mitigation system is about the same as for other common home repairs.*

## RADON IN WATER

There are two main sources for the radon in your home's indoor air, the soil and the water supply. Compared to radon entering the home through water, radon entering your home through the soil is usually a much larger risk.

The radon in your water supply poses an inhalation risk and an ingestion risk. Research has shown that your risk of lung cancer from breathing radon in air is much larger than your risk of stomach cancer from swallowing water with radon in it. Most of your risk from radon in water comes from radon released into the air when water is used for showering and other household purposes.

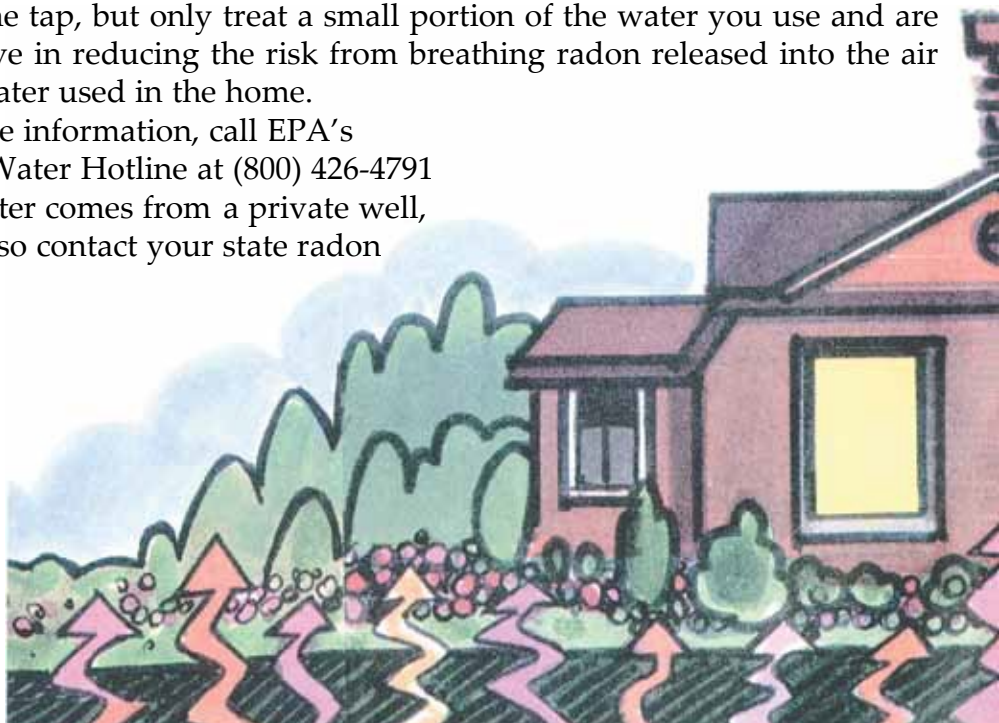
Radon in your home's water is not usually a problem when its source is surface water. A radon in water problem is more likely when its source is ground water, e.g., a private well or a public water supply system that uses ground water. If you are concerned that radon may be entering your home through the water and your water comes from a public water supply, contact your water supplier.

If you've tested your private well and have a radon in water problem, it can be fixed. Your home's water supply can be treated in two ways. Point-of-entry treatment can effectively remove radon from the water before it enters your home. Point-of-use treatment devices remove radon from your water at the tap, but only treat a small portion of the water you use and are not effective in reducing the risk from breathing radon released into the air from all water used in the home.

For more information, call EPA's Drinking Water Hotline at (800) 426-4791. If your water comes from a private well, you can also contact your state radon office.



***If you've tested the air in your home and found a radon problem, and your water comes from a well, have your water tested.***



# HOW TO LOWER THE RADON LEVEL IN YOUR HOME

Since there is no known safe level of radon, there can always be some risk. But the risk can be reduced by lowering the radon level in your home.

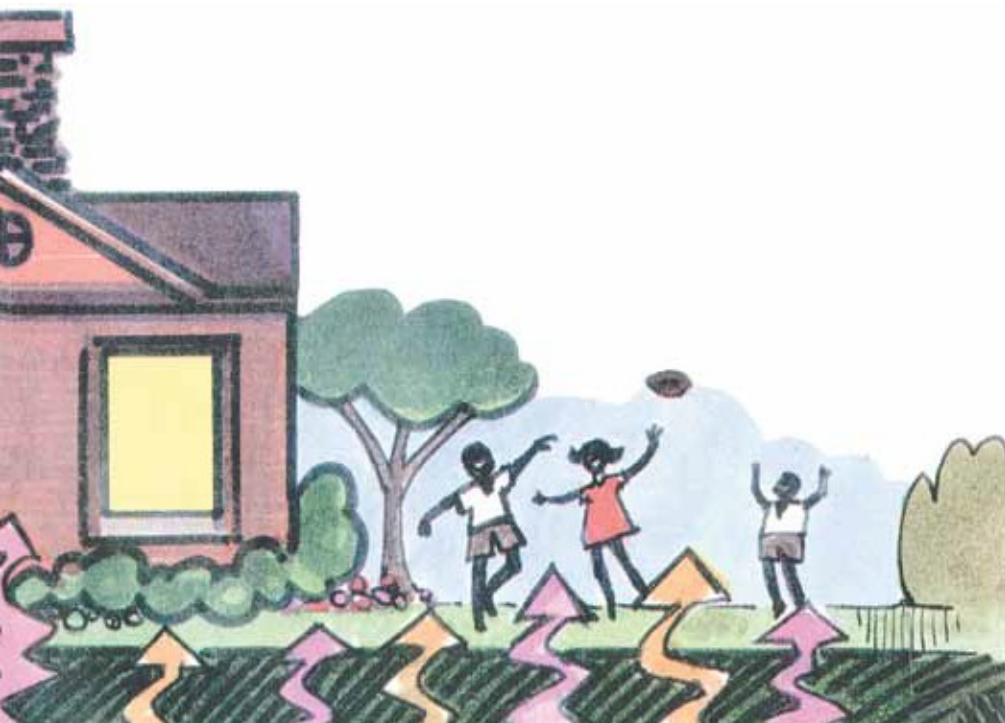
There are several proven methods to reduce radon in your home, but the one primarily used is a vent pipe system and fan, which pulls radon from beneath the house and vents it to the outside. This system, known as a soil suction radon reduction system, does not require major changes to your home. Sealing foundation cracks and other openings makes this kind of system more effective and cost-efficient. Similar systems can also be installed in houses with crawl spaces. Radon contractors can use other methods that may also work in your home. The right system depends on the design of your home and other factors.

Ways to reduce radon in your home are discussed in EPA's *Consumer's Guide to Radon Reduction*. You can get a copy at [-about-radon https://www.epa.gov/radon/publications-about-radon](https://www.epa.gov/radon/publications-about-radon).

The cost of reducing radon in your home depends on how your home was built and the extent of the radon problem. Most homes can be fixed for about the same cost as other common home repairs. The cost to fix can vary widely; consult with your state radon office or get one or more estimates from qualified mitigators. The cost is much less if a passive system was installed during construction.

## **RADON AND HOME RENOVATIONS**

*If you are planning any major structural renovation, such as converting an unfinished basement area into living space, it is especially important to test the area for radon before you begin the renovation. If your test results indicate a radon problem, radon-resistant techniques can be inexpensively included as part of the renovation. Because major renovations can change the level of radon in any home, always test again after work is completed.*





# HOW TO LOWER THE RADON LEVEL IN YOUR HOME *continued*

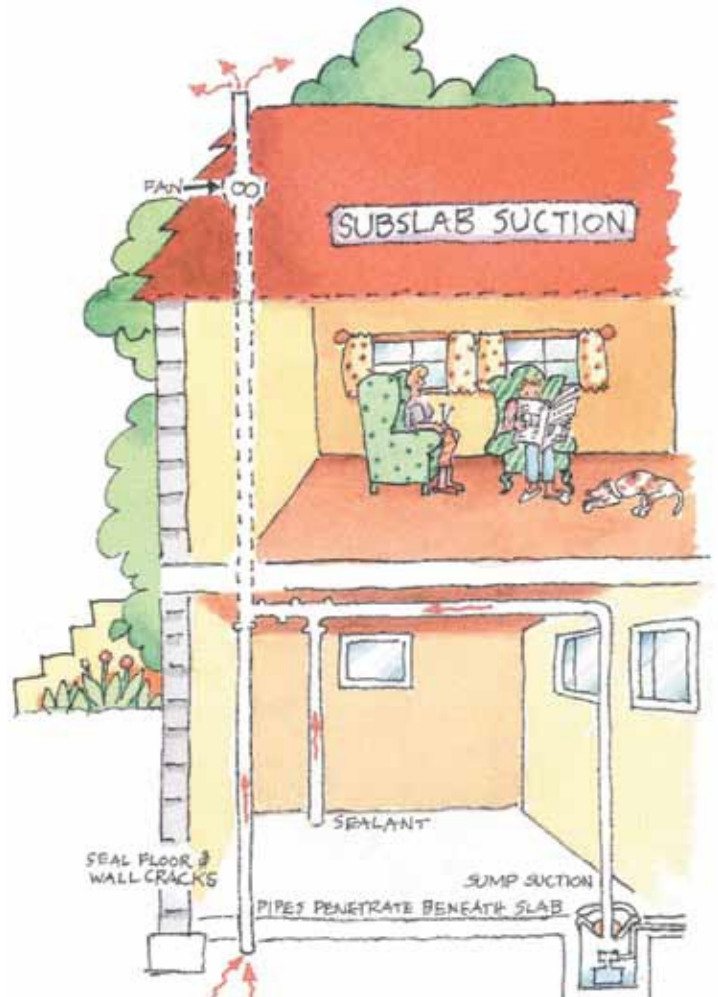
**Most homes can be fixed for about the same cost as other common home repairs.**

Lowering high radon levels requires technical knowledge and special skills. You should use a contractor who is trained to fix radon problems. A qualified contractor can study the radon problem in your home and help you pick the right treatment method.

Check with your state radon office for names of qualified or state certified radon contractors in your area. You can also contact private radon proficiency programs for lists of privately certified radon professionals in your area. For more information on private radon proficiency programs, visit <https://www.epa.gov/radon/find-radon-test-kit-or-measurement-and-mitigation-professional>. Picking someone to fix your radon problem is much like choosing a contractor for other home repairs—you may want to get references and more than one estimate.

*If you are considering fixing your home's radon problem yourself, you should first contact your state radon office for guidance and assistance (<https://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information>).*

You should also test your home again after it is fixed to be sure that radon levels have been reduced. Most soil suction radon reduction systems include a monitor that will indicate whether the system is operating properly. In addition, it's a good idea to retest your home every two years to be sure radon levels remain low.



*Note: This diagram is a composite view of several mitigation options. The typical mitigation system usually has only one pipe penetration through the basement floor; the pipe may also be installed on the outside of the house.*

# THE RISK OF LIVING WITH RADON

Radon gas decays into radioactive particles that can get trapped in your lungs when you breathe. As they break down further, these particles release small bursts of energy. This can damage lung tissue and lead to lung cancer over the course of your lifetime. Not everyone exposed to elevated levels of radon will develop lung cancer. And the amount of time between exposure and the onset of the disease may be many years.

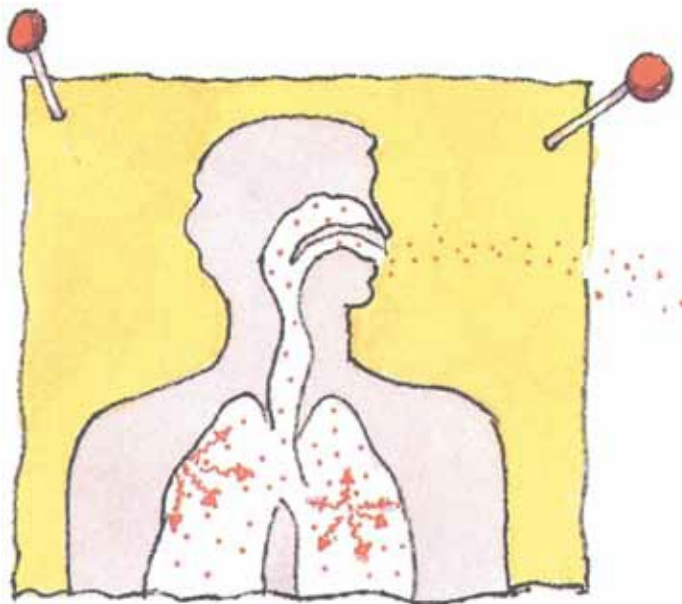
Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks. However, we know more about radon risks than risks from most other cancer-causing substances. This is because estimates of radon risks are based on studies of cancer in humans (underground miners).

Smoking combined with radon is an especially serious health risk. Stop smoking and lower your radon level to reduce your lung cancer risk.

Children have been reported to have greater risk than adults of certain types of cancer from radiation, but there are currently no conclusive data on whether children are at greater risk than adults from radon.

***Your chances of getting lung cancer from radon depend mostly on:***

- *How much radon is in your home*
- *The amount of time you spend in your home*
- *Whether you are a smoker or have ever smoked*



***Scientists are more certain about radon risks than risks from most other cancer-causing substances.***

## RADON RISK IF YOU SMOKE

Radon Level	If 1,000 people who smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO: Stop Smoking and...
20 pCi/L	About 260 people could get lung cancer	↳ 250 times the risk of drowning	Fix your home
10 pCi/L	About 150 people could get lung cancer	↳ 200 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 120 people could get lung cancer	↳ 30 times the risk of dying in a fall	Fix your home
4 pCi/L	About 62 people could get lung cancer	↳ 5 times the risk of dying in a car crash	Fix your home
2 pCi/L	About 32 people could get lung cancer	↳ 6 times the risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 20 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L		(Average outdoor radon level)	

Note: If you are a former smoker, your risk may be lower.

**It's never too late to reduce your risk of lung cancer. Don't wait to test and fix a radon problem. If you are a smoker, stop smoking.**

## RADON RISK IF YOU'VE NEVER SMOKED

Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO:
20 pCi/L	About 36 people could get lung cancer	↳ 35 times the risk of drowning	Fix your home
10 pCi/L	About 18 people could get lung cancer	↳ 20 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 15 people could get lung cancer	↳ 4 times the risk of dying in a fall	Fix your home
4 pCi/L	About 7 people could get lung cancer	↳ The risk of dying in a car crash	Fix your home
2 pCi/L	About 4 people could get lung cancer	↳ The risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 2 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L		(Average outdoor radon level)	

Note: If you are a former smoker, your risk may be higher.

\*Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003).

\*\*Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.

# RADON MYTHS AND FACTS

**MYTH:** Scientists aren't sure radon really is a problem.

**FACT:** Although some scientists dispute the precise number of deaths due to radon, all major health organizations (like the Centers for Disease Control, the American Lung Association and the American Medical Association) agree with estimates that radon causes thousands of preventable lung cancer deaths every year. This is especially true among smokers, since the risk to smokers is much greater than to non-smokers.

**MYTH:** Radon testing is difficult, time consuming and expensive.

**FACT:** Radon testing is easy. You can test your home yourself or hire a qualified radon test company. Either approach takes only a small amount of time and effort.

**MYTH:** Homes with radon problems can't be fixed.

**FACT:** There are simple solutions to radon problems in homes. Hundreds of thousands of homeowners have already fixed radon problems in their homes. Most homes can be fixed for about the same cost as other common home repairs; check with one or more qualified mitigators. Call your state radon office ([www.epa.gov/radon/wherelive.html](http://www.epa.gov/radon/wherelive.html)) for help in identifying qualified mitigation contractors.

**MYTH:** Radon only affects certain kinds of homes.

**FACT:** House construction can affect radon levels. However, radon can be a problem in homes of all types: old homes, new homes, drafty homes, insulated homes, homes with basements, homes without basements. Local geology, construction materials, and how the home was built are among the factors that can affect radon levels in homes.

**MYTH:** Radon is only a problem in certain parts of the country.

**FACT:** High radon levels have been found in every state. Radon problems do vary from area to area, but the only way to know your radon level is to test.

**MYTH:** A neighbor's test result is a good indication of whether your home has a problem.

**FACT:** It's not. Radon levels can vary greatly from home to home. The only way to know if your home has a radon problem is to test it.

## RADON MYTHS AND FACTS *continued*

**MYTH:** Everyone should test their water for radon.

**FACT:** Although radon gets into some homes through water, it is important to first test the air in the home for radon. If your water comes from a public water system that uses ground water, call your water supplier. If high radon levels are found and the home has a private well, call the Safe Drinking Water Hotline at (800) 426-4791 for information on testing your water.

**MYTH:** It's difficult to sell homes where radon problems have been discovered.

**FACT:** Where radon problems have been fixed, home sales have not been blocked or frustrated. The added protection is sometimes a good selling point.

**MYTH:** I've lived in my home for so long, it doesn't make sense to take action now.

**FACT:** You will reduce your risk of lung cancer when you reduce radon levels, even if you've lived with a radon problem for a long time.

**MYTH:** Short-term tests can't be used for making a decision about whether to fix your home.

**FACT:** A short-term test followed by a second short-term test\* can be used to decide whether to fix your home. However, the closer the average of your two short-term tests is to 4 pCi/L, the less certain you can be about whether your year-round average is above or below that level. Keep in mind that radon levels below 4 pCi/L still pose some risk. Radon levels can be reduced in most homes to 2 pCi/L or below.

\*If the radon test is part of a real estate transaction, the result of two short-term tests can be used in deciding whether to mitigate. For more information, see EPA's "Home Buyer's and Seller's Guide to Radon."

# FOR FURTHER INFORMATION

## EPA Radon Website

<https://www.epa.gov/radon>

EPA's radon page includes links to publications, hotlines, private proficiency programs and more.

Frequent Questions:

<https://iaq.zendesk.com/hc/en-us/sections/202349927>

## Radon Hotlines

**1-800-SOS-RADON (767-7236)\***

Purchase radon test kits by phone.

**1-800-55RADON (557-2366)\***

Get live help for your radon questions.

**1-800-644-6999\***

Radon Fix-It Hotline. For general information on finding or reducing the radon level in your home.

**1-866-528-3187\***

Línea Directa de Información sobre Radón en Español. Hay operadores disponibles desde las 9:00 AM hasta las 5:00 PM para darle información sobre radón y como ordenar un kit para hacer la prueba de radón en su hogar.

**1-800-426-4791**

Safe Drinking Water Hotline. For general information on drinking water, radon in water, testing and treatment, and standards for radon in drinking water. Operated under a contract with EPA.

\*Operated by Kansas State University in partnership with EPA.

## EPA Regional Offices

<https://www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information>. Check the above website for a listing of your EPA regional office.

## Ordering Radon Publications

Many EPA radon publications are available from <https://www.epa.gov/radon/publications-about-radon>

Radon publications may be ordered through the National Service Center for Environmental Publications (NSCEP) by calling 1-800-490-9198, by visiting the NSCEP website at <https://www.epa.gov/nscep> or by email at [nscep@lmsolas.com](mailto:nscep@lmsolas.com).



## Surgeon General Health Advisory

*“Indoor radon is the second-leading cause of lung cancer in the United States and breathing it over prolonged periods can present a significant health risk to families all over the country. It’s important to know that this threat is completely preventable. Radon can be detected with a simple test and fixed through well-established venting techniques.”*

January 2005

## U.S. EPA Assessment of Risks from Radon in Homes

In June 2003, the EPA revised its risk estimates for radon exposure in homes. EPA estimates that about 21,000 annual lung cancer deaths are radon related. EPA also concluded that the effects of radon and cigarette smoking are synergistic, so that smokers are at higher risk from radon. EPA’s revised estimates are based on the National Academy of Sciences 1998 BEIR VI (Biological Effects of Ionizing Radiation) Report which concluded that radon is the second leading cause of lung cancer after smoking.



Indoor Environments Division (6609J)  
EP 402/K-12/002 | May 2012 | [www.epa.gov/radon](http://www.epa.gov/radon)

Dear Resident,

Radon is a naturally occurring colorless, odorless gas that is a by-product of the decay of radioactive materials in bedrock and soil that is potentially present in some homes at concentrations that are dangerous to tenants. Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers in the U.S.

An important step is being taken to lower your risk of lung cancer. A radon test is being scheduled for the property and will be set in your home for a minimum of two days. Test detectors are not dangerous. A *Citizen's Guide to Radon* is available on the Environmental Protection Agency's (EPA's) website.

***Required Closed-Building Conditions***

- Closed building conditions must be maintained for 12 hours prior to initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to combustion appliances.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

Tentative detector placement Day \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Tentative detector pick-up Day \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

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

Sincerely,

Denver Housing Authority  
1035 Osage Street  
Denver, CO 80204