Radon Testing for Multifamily Buildings

This document provides Oregon property owners and managers with a protocol to accurately test for elevated radon levels in multifamily buildings.







Oregon Health Authority
PUBLIC HEALTH DIVISION

Acknowledgments

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The content of this protocol was reviewed by Home Forward and the Northwest Radon Coalition.

Please send any comments about this document to:

Oregon Health Authority Public Health Division
800 N.E. Oregon Street, Suite 640
Portland, OR 97232.

Phone: 971-673-0440

Email: radon.program@dhsoha.state.or.us

Web: www.healthoregon.org/radon

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Introduction

Radon is the number-one cause of lung cancer among non-smokers, according to EPA estimates. Although no amount of radon is safe, people can take steps to reduce its potential for harm.

Measuring and reducing elevated radon at home is the most effective way to decrease harm from radon.

Elevated radon is found throughout Oregon and in a variety of structures. The only way to know if a building has elevated radon is to test.

The Oregon Health Authority (OHA) produced this guide to help Oregon multifamily building owners and managers accurately test their buildings for elevated radon. This guide follows current national guidelines for measuring radon in multifamily apartment buildings (1).

This protocol's appendices contain frequently asked questions, step-by-step instructions and other tools to help owners and managers plan and carry out radon testing.

Thank you for the part you play in raising radon awareness.

Oregon Health Authority

Public Health Division, Radon Awareness Program

Protocol objectives

This protocol will allow multifamily building owners and property managers to:

1. Accurately carry out testing multifamily buildings for elevated radon levels.
2. Understand the components of radon and radon testing. This will help multifamily building owners and managers use appropriate terms and communicate their definitions to others.
3. Understand the laws and basic science behind radon and radon testing. This includes understanding the presence of radon in the environment and how radon enters buildings.
4. Forecast how, when, where and why radon occurs and predict how radon will behave at different times, in different places and under different circumstances.
5. Know and use the appropriate units of measurement, measure radon concentrations and interpret the test results' validity and reliability.
6. Use standard devices approved for radon measurement. This includes understanding device calibration, servicing and potential errors related to misuse or misplacement.
7. Understand the value of a quality-controlled approach to testing and use quality control and quality assurance throughout the testing process.
8. Comply with existing laws, regulations and other established testing requirements.
9. Understand the processes associated with basic radon mitigation.

What is radon?

Radon comes from natural deposits of uranium in the soil. It is found everywhere in the world. Uranium naturally decays into radium, which further breaks down into radon gas. Some geographic areas have more radon than others. Any building can have elevated levels of radon and no level of exposure is safe. The only way to know a building's radon level is to test it.

Because radon is a gas, it can move up through the soil and enter buildings through crawl spaces, foundation cracks and other places. The highest radon concentration is usually in the lowest parts of the building. Once radon enters a building, it spreads easily through the air and continues to break down. The radon decay products are high in energy and can cause lasting damage to lung tissue.

Why is radon a problem?

Radon is a naturally occurring gas that is colorless, odorless and tasteless. It is radioactive and travels through the soil into buildings through cracks and openings in the foundation. This can occur in buildings or homes of any age and type (with or without basements). Eventually, radon breaks down into radioactive decay particles that can be trapped in the lungs when people breathe. As these particles break down, they release small bursts of radiation. This radiation damages lung tissue and can lead to lung cancer over time.

Radon is a human carcinogen, meaning exposure over time can cause cancer. In this case, exposure to elevated radon over time increases the risk of lung cancer. The full extent of the health risks of radon are not known. However, investigating its negative effects on underground miners and other exposed groups has confirmed that prolonged human exposure to radon poses a greater threat than exposure to other known carcinogens such as glyphosate (Roundup) and flame-retardant chemicals like polybrominated biphenyls (PBBs).

Breathing radon for extended periods can present a significant health risk (2). Radon is the leading cause of lung cancer for non-smokers in the United States and increases the risk of lung cancer for smokers. The Surgeon General has warned the public about the health risk from exposure to radon in indoor air and urges everyone to perform radon testing (3). Other health agencies, including the U.S. Centers for Disease Control and Prevention and the World Health Organization, have made similar conclusions about radon's danger to human health.

Radon and lung cancer

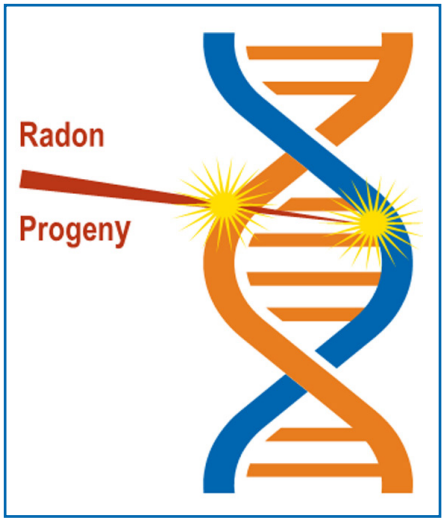
The U.S. Environmental Protection Agency (EPA) ranks radon in the highest classification of cancer-causing substances — group A. This category only includes substances with enough evidence to show they cause cancer in humans.

EPA's classification of cancer-causing agents:

- Group A: Known human carcinogen (for example, radon)
- Group B: Probable carcinogenic (for example, glyphosate; polybrominated biphenyls)
- Group C: Possibly carcinogenic
- Group D: Not classifiable (no data), and
- Group E: Evidence of non-carcinogenicity

How does radon cause cancer?

When radon gas breaks down, it creates solid radioactive particles known as *progeny*. These very small radioactive particles can attach to surfaces in your home or to particles in the air, such as dust and smoke. When the progeny are inhaled, it can increase the risk of lung cancer if exposed over long period of time.



DNA is the basic building block for all our body's structures. The DNA building block is coded into cells. Cells are continually reading their DNA code so they can construct fresh molecules for body cells and organs.

Radon progeny exert small bursts of energy (radiation) on lung tissue and cause damage. They can even strike and disrupt the cell DNA, which damages the cancer suppressant gene and increases the risk of developing cancer. This process takes place very quickly, but the effects take much longer to surface.

The risk of lung cancer is based on how much radon a person is exposed to and for how long. Scientific research indicates that it may take 10- to 20-years of exposure before lung cancer develops.

The EPA estimates that more than 21,000 radon-related lung cancer deaths occur each year in the United States. Below is a table of estimated U.S. deaths from different cancer types in 2015. If radon-induced lung cancer were its own category, it would be our country's eighth leading cause of death from cancer.

Cancer types and estimated U.S. deaths, 2015 (4)

Cancer type	Estimated U.S. deaths in 2015
1. Lung and bronchus	158,040
2. Colon and rectum	49,700
3. Breast cancer	40,730
4. Pancreas	40,560
5. Prostate	27,540
6. Liver and bile duct	24,550
7. Leukemia	24,450
Radon-induced lung cancer	**21,000**
8. Lymphoma	20,940
9. Urinary bladder	16,000
10. Esophagus	15,500
11. Ovary	14,180

The National Research Council estimates that radon exposure cause between 15,400 and 21,800 deaths per year in the United States. This range includes never-smokers and ever-smokers (people who have smoked at least 100 cigarettes in their lives) (5).

Not everyone who breathes in radon or radon decay products will develop lung cancer. A person's risk of lung cancer depends mostly on the concentration of radon, the length of time they were exposed (over their lifetime), their genetics and their overall health. 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 non-smokers.

Radon does not cause any short-term health symptoms such as shortness of breath, coughing, headaches or fever. Children have higher respiration rates than adults and are reported to be at greater risk for certain types of cancer from radiation. However, currently there isn't conclusive data showing children are at greater risk from radon. There is also no conclusive evidence that radon exposure causes illnesses other than lung cancer.

How is radon reported?

In the United States, radioactive materials are measured in curies. A curie is the amount of radioactivity released from one gram of radium. A picocurie is a millionth of a millionth, or a trillionth, of a curie. Radon is measured and reported in picocuries per liters of air (pCi/L).

What radon studies have been completed?

As early as 1987, studies (6) revealed drastic differences in radon concentration levels across the country. Some regions reported that 55 percent of homes had radon concentrations greater than 4.0 pCi/L, the action level determined by the EPA.

What is the U.S. EPA action level?

U.S. EPA recommends reducing indoor air radon concentrations to below the radon action level of 4.0 pCi/L. This level is not health-based; there is no safe level of radon exposure. Radon levels in most buildings can be lowered below 4.0 pCi/L, but it depends on the characteristics of the building and the underlying geology.

Because outdoor levels of radon across the country average 0.4 pCi/L, it's not possible to reduce our radon exposure to zero. Although no amount of radon is good, the goal is to reduce radon levels to reduce potential harm.

Where do we spend our time?

One study for the U.S. EPA shows that we spend 87.9 percent of our daily time indoors (7). Because many people, particularly children, spend much of their time at home, the home is the most likely source of radon exposure. The EPA estimates that one in 15 U.S. homes have elevated radon levels (8). Some areas of Oregon have higher radon levels than others, but no area is risk free.

How does radon enter buildings?

Many factors contribute to radon entering homes and buildings. Homes and buildings that are in the same community can have very different radon levels. Building owners and managers cannot know if their buildings have elevated radon levels without testing.

Radon levels in buildings

The level of radon in a building depends on:

- The concentration of uranium and radium in the soil under the building.
- How easily the radon can travel into the building through loose soil, foundation cracks and openings into the building.
- Differences between the air pressure inside a building and in the soil and space under the building. Warm indoor air leaving the upper parts of a building is naturally replaced by colder air from below; this is called the "stack effect."
- How easily air travels through the building.
- The ventilation rate of the building.

The air pressure in your building is lower than pressure in the soil under your building's foundation. This difference in pressure makes your building act like a vacuum that sucks radon in through foundation cracks and other openings.

Entry through pressure-driven transport

The most common way for radon to enter a building is from the underlying soil through pressure-driven transport. Pressure-driven transport occurs when a lower indoor air pressure draws air from the soil or bedrock into the building.

For radon to travel through soil into a building, it needs:

- **A driving force**, such as greater air pressure in the soil under the building than the pressure inside the building
- **A pathway into the building**, such as loose, permeable soil, utility trenches and crawl spaces, and
- **Openings in the foundation**, such as joints, cracks, bare earth areas and penetrations through the foundation for utilities.

Large buildings usually have lower inside air pressure than the surrounding soil. This can create very small vacuums called "air pressure differentials." Air pressure differentials allow radon outside or underneath the building to be sucked inside. The design and operation of heating, ventilation and air-conditioning (HVAC) systems may also depressurize the building and make it easier for radon to enter.

Entry through diffusion

Radon can also enter buildings when there isn't a pressure difference. This type of radon movement is called "diffusion-driven transport." Diffusion is what causes a drop of food coloring placed in a glass of water to spread through the entire glass.

Diffusion-driven transport is rare. It is highly unlikely that diffusion is the major cause of elevated radon levels in multifamily buildings. Many large buildings are built with slab-on-grade construction. This type of construction allows radon gas to enter through the foundation, cracks in the slab and expansion joints between the slabs.

Entry through other mechanisms

Other places radon can enter include:

- Basement areas
- Crawl spaces
- Utility tunnels
- Heating, ventilation and air conditioning (HVAC) ducts
- Sumps
- Drains, and
- Cracks or other holes in the slab.

Man-made pathways

- The construction process can disturb the natural ground and make it more porous.
- Utility and water lines are often installed in trenches with loose soil or gravel that allows radon to move easily.

Slab penetrations

- There are often openings in the slab for plumbing pipes.
- Most penetrations in the slab are hidden during construction and not sealed.

Plumbing block-outs

- Radon follows plumbing through block-out sections. Block-out sections are barriers within a concrete foundation wall that allow mechanical pipes to pass through.

Entry through well water

Another way radon can enter a building is through well (or spring) water. In certain areas of the country, well water supplied directly to a building may come in contact with radium. This water may release radon gas into the building once it is inside. It takes high levels of radon in well water to raise radon gas levels in buildings. For example, 10,000 pCi/L of radon in well water is expected to increase the radon in a structure by 1.0 pCi/L by itself.

Most elevated radon in buildings will come from the soil underneath, not the well water. The only known health risk associated with radon in water is exposure to the airborne radon released when the water is used. For more information on well water quality, visit the Oregon Domestic Well Safety Program at www.healthoregon.org/wells.

Entry through building materials

Radon can also come from building materials, such as concrete, brick, fireplace stones, granite and sheet rock, which may contain some radium. However, this rarely causes high radon in large buildings. The extent of the radium-contaminated building materials is unknown, but it is believed to be very small.

Entry through HVAC systems

The design, operation and maintenance of a building's HVAC system can change radon levels in multifamily buildings through ventilation. Increasing ventilation dilutes the indoor radon concentration by bringing fresh air inside. However, if an HVAC system decreases the building's ventilation, this allows radon gas to build up. With good ventilation, HVAC systems can carry radon from areas of high concentration to areas of low concentration.

Multifamily buildings may have overall air quality concerns. Low intake of outside air causes poor indoor air quality in many large buildings. It can also increase concentration of common asthma triggers such as mold and dust mites. The frequency and thoroughness of HVAC maintenance plays an important role. Air intake filters must be periodically cleaned and changed. Otherwise, they can greatly reduce the amount of outdoor air ventilating inside. Less ventilation allows radon to build up indoors.

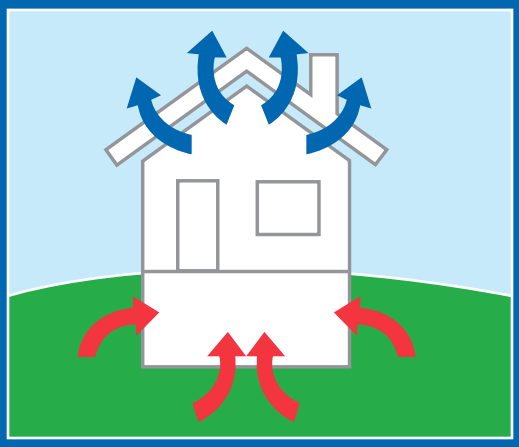
Understanding the design, operation and maintenance of a multifamily building's HVAC system is essential for understanding and managing a radon problem.

Environmental factors that affect radon concentrations

Seasonal weather changes and outside temperatures can affect radon concentrations. Radon levels can also vary throughout the day as temperatures and air pressures change.

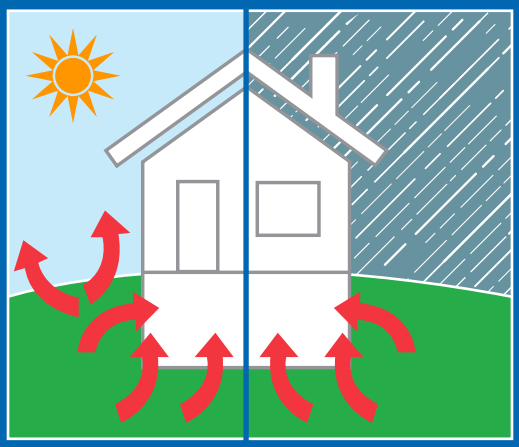
We expect lower radon concentrations in the summer. Warm temperatures mean better ventilation due to open doors and windows and use of air conditioning. In the warmer months, radon levels are mainly influenced by the geology under the building. However, residents can also cause radon levels to rise by accidently blocking HVAC air returns.

Environmental effects: frost or other factors that "cap" soil



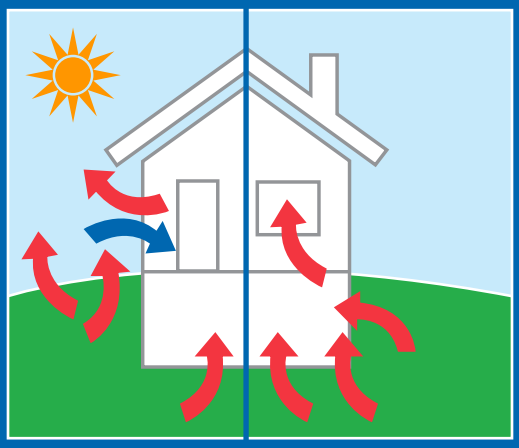
- Frost can "cap" the soil. This causes the negative pressure in buildings to draw soil gas from a larger area.
- Asphalt aprons around large buildings can have the same effect.

Rain effects



- Rain can "cap" the soil.
- It can force radon through cracks and gaps into the building.
- Rain is often accompanied with barometric pressure changes.

Effects of open windows



- Open windows reduce vacuum effects , which reduces radon entry into buildings.
- Open windows increases ventilation and dilutes radon.
- Keeping windows open can help reduce radon levels. However, a well-ventilated building may still have high radon levels.

What rooms or units should be tested?

According to the EPA, radon levels in large buildings often vary greatly from unit to unit. They can even vary from room to room within the same unit.

Because of these variations, radon testing teams must measure for radon in all apartments, rooms used as office space and common areas that are in contact with the ground or sit above crawl spaces, utility tunnels or enclosed parking garages. Radon can also travel to upper floors. During testing, a small percentage of upper floor units will be tested. Hallways and stairwells might also be tested if radon presence is suspected.

Multifamily building testing

- All units and areas of a building that have been selected for testing should be tested at the same time.
- Test the lowest level of a building or unit, even if it's not currently lived in or used by residents or building personnel.
- Test any ground floor areas that could be converted to living spaces in the future.
- Test any areas that are occupied for more than four hours a day, such as laundry rooms, meeting spaces or offices.
- Test areas that freely exchange air with living spaces, such as stairwells and elevator shafts.
- A minimum of one detector for every 2,000 square feet of open floor space is required.

- On upper floors, test 10 percent of the units on each floor, rounding up. For example, if there are 18 units on an upper floor, you must test 1.8 or 2 units. If the floor has fewer than 10 units, test at least 1. Increase if there are areas of free air exchange with the lower floors, such as stairways, elevators or utility tunnels.

Types of radon testing devices

There are two main types of radon test kits:

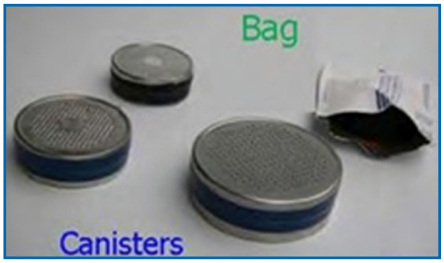
1. Passive devices, which don't need power to operate.
2. Active devices, also called continuous devices, which do need power to operate (such as batteries, DC adaptors or wall outlets).

Passive devices that don't need power are exposed to indoor air by being "uncapped" and then left in place for a length of time called the testing period.

Active devices that do need power record changes in the concentrations of radon and radon decay products several times a day throughout the testing period.

Passive devices

Activated charcoal devices (**ACs**) are passive devices with charcoal that has been "activated" or treated in a way that allows it to better adsorb gases. After testing, these devices are sent to a lab that reads the concentrations of the gases they adsorbed.



Testing conditions should be carefully controlled during the entire testing period. If the radon exposure varies greatly during the test, it can cause errors. Also, ACs must be sent to the testing lab immediately after the test is done using a mail service that guarantees two-day delivery. **Overnight delivery is preferred**.

Different types of ACs are available. One common AC device uses charcoal packaged inside a breathable bag. Radon diffuses into the bag and is adsorbed onto the charcoal. Another device is a round container filled with activated charcoal. One side of the container has a screen that keeps the charcoal in but allows air to enter and be adsorbed by the charcoal.

How activated charcoal devices (ACs) work

- Open the container and place it in unit or area you are testing.
- Radon gas enters the charcoal and is trapped along with any radon decay products.

- At the end of the testing period, seal the container and send it to the lab for analysis.
- The lab counts the amount of decay from the radon in the charcoal with a gamma detector. The lab uses this information to calculate the radon concentration.

AC detectors are used for two to seven day test periods. The exact test period depends on the type of device. Some devices have a diffusion barrier over the charcoal to reduce the effects of drafts and high humidity.

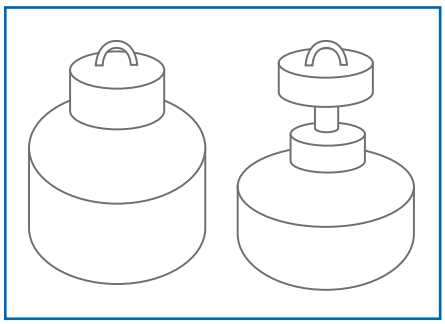
Advantages of ACs:

- Accurate
- Inexpensive
- Do not require power
- Can be sent through the mail
- Do not need special training to use

Disadvantages of ACs:

- Must be analyzed by a lab immediately after removal from the building
- Highly sensitive to humidity
- No way to detect tampering
- Results are biased toward the last 24 hours of the testing period

Electret-ion chambers (EICs) are also passive devices. They are known as "true integrating" devices. They are better at measuring average radon concentrations.



When radon and radon decay particles breakdown, they emit electrical charges onto the airborne particles that are released. These charged particles are attracted to a charged disc in the EIC inner chamber. When they hit the disc, it loses some of its electrical charge. That difference in charge relates to the average radon concentration in the chamber. EICs can measure for short periods (two to seven days) or for longer periods (up to one year).

How they work:

- The plunger at the top opens and closes the device. When open, radon gas enters the chamber.
- As the radon gas inside the chamber decays, it creates charged particles that are attracted to the charged Teflon® disc. These charged particles (radon decay products) reduce the electric charge on the disc by small amounts.
- When the test is completed, the disc is removed from the chamber and its voltage is measured with a specialized reader. The test administrator will have to send the disc to a lab if they do not have a specialized voltage reader.
- The specialized reader was also used to read the disc before the kit was sent out. The difference between the electric charge before and after testing is used to calculate the average radon concentration.
- There are both short-term and long-term EICs. These are commonly called ES (short-term) and EL (long-term). ES are used for tests of two to seven days and EL are used for tests of one to 12 months.

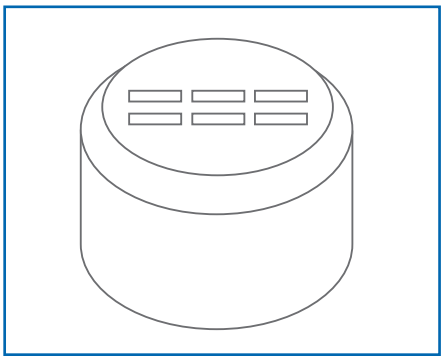
Advantages of EICs:

- Get results immediately
- Does not require power
- Can be recharged and reused

Disadvantages of EICs:

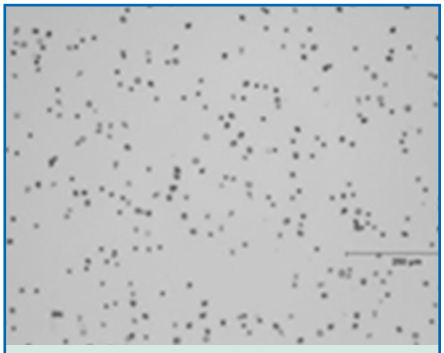
- Sensitive to background radiation
- Sensitive to altitude
- Voltage measurements must be done at the same temperature
- Difficult to detect tampering

Alpha track detectors are kits with a small piece of plastic or film inside a container with a filter-covered opening. Radon diffuses into the container. As the radon gas breaks down, its decay products strike the detector and produce submicroscopic damage to the plastic or film.



At the end of the test period, the detectors are returned to a lab. The strikes are counted using a microscope

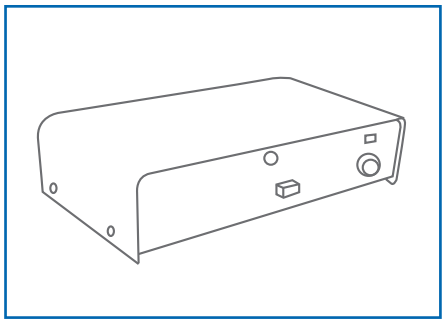
and the lab technicians mathematically correlate the number of strikes to the radon concentration in the air. These kits are usually used for long-term radon tests that run from three to 12 months.



Microscopic scratches caused by radon decay products.

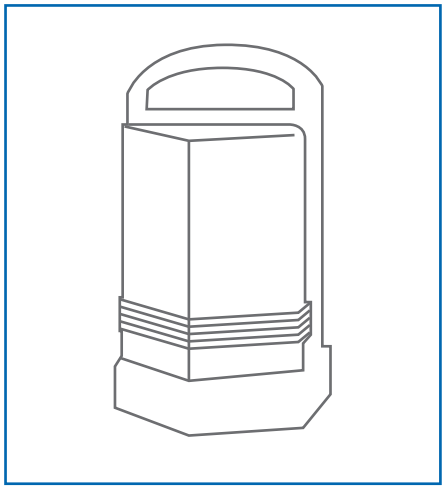
Active devices

Active devices include continuous radon monitors (CRMs), which have a power source. The device collects air samples either mechanically or passively and uses a detection monitor to read radon concentrations. CRMs have the highest accuracy and precision over short measurement periods.



Advantages of CRMs:

- Records radon levels in regular time periods (often hourly)
- Users can review readings to pinpoint the times of day radon is higher
- Results can be used to adjust HVAC systems to increase ventilation when radon levels are high



Short- and long-term tests

There are two ways to use radon test kits (passive or active) for radon testing:

Short-term — A short-term test is the quickest way to test for radon. In this test, the testing device remains undisturbed in the units for two to 90 days. The time period depends on whether the devices are passive or active.

- Activated charcoal (AC) devices are simple to operate and place. The test kits can be purchased in hardware, department or home improvement stores or ordered through the mail or online. They can also be purchased in bulk at a discounted rate. Please note: AC kits require "closed-building conditions" before and during the test, per kit instructions. See Appendix B and the glossary for more about closed-building conditions.
- Electret-ion chamber (EIC) devices are also simple to operate and place but may be more expensive to buy and implement.

Long-term — A long-term test remains in place for more than 90 days. Long-term test results are more likely to represent an average year's exposure in that dwelling. Long-term tests do not require closed building conditions.

- Alpha track detectors are simple to operate and place but are slightly more expensive and test results take longer to get.

Short-term, passive testing devices are recommended for initial measurements of multifamily buildings.

How to build a testing strategy

To measure radon levels, start with a short-term test. If the initial test shows radon levels below 4 pCi/L, no additional testing is needed at this time. If levels are unusually high, a short-term test will provide immediate results that allow owners and managers to notify tenants quickly.

To get valid test results, only use devices that measure test periods of at least 48 continuous hours. Follow the testing steps below.

Step 1: Initial measurements of radon levels

Short-term tests provide the fastest indicators of high radon concentrations. Initial measurements should be short-term tests that run between two and seven days. Place a testing device in each ground-contact unit and frequently used common spaces, such as community meeting rooms, offices and laundry facilities associated with the building.

A unit is "ground-contact" if it has floors or walls in contact with the ground. In addition, place devices in each unit that exists over crawl spaces, utility tunnels, or enclosed parking garages. Test in the lowest level of a unit, even if it is not currently being used, but could serve as a den, playroom, office, work area or additional bedroom in the future.

For higher level floors, place a testing device in at least one unit on each floor. The total number of test devices on upper floors must equal at least 10 percent of the number of units on that floor. So, if the first floor has 16 units, you need to test at least 1.6 or 2 units on each upper floor (always round up).

Short-term test kits should be done during colder months (October through March) when windows and doors are normally closed.

- It is best to begin short-term testing in early October in case long-term testing is required after.
- Assess the buildings to decide the number of testing devices needed. See the "Quality assurance procedures for multifamily building radon testing program" section on page 28 for information on how to calculate the total number of testing devices.

This will include extra devices for quality assurance (blanks and duplicates) that this protocol will discuss later.

- Frequently used rooms include offices, laundry facilities, lobbies, exercise rooms, communal kitchen areas and HVAC and mechanical rooms. All rooms should be tested at the same time.
- In open areas need at least one test kit per 2,000 square feet of space. For example, a 3,500 square-foot gym would require two test kits.
- All tenants and building or maintenance personnel should be aware that units and other areas are being tested.
- **"Closed-building conditions" must be observed for short-term testing. See the "Test kit placement guide" in Appendix A for more information.**

Step 2: Follow-up testing

If the radon testing results in any units or frequently occupied areas are 4.0 pCi/L or greater, you must do follow-up testing. Additionally, EPA and OHA recommend doing this follow-up testing before making any mitigation decisions. Follow-up testing should start quickly, ideally within one month of receiving initial test results.

Based on the results of a unit or area's initial short-term test, the following steps should be conducted:

- If the result is less than 2.0 pCi/L, the U.S. Department of Housing and Urban Development (HUD) recommends following American Association of Radon Scientists and Technologists (AARST) guidelines when deciding when to retest multifamily buildings. Retesting is recommended every 5 years or after major remodels.
- If the result is between 2.0 pCi/L and 4.0 pCi/L, consider taking steps to lower the radon in that unit or area.
- If the result is from 4.0 pCi/L to 8.0 pCi/L, perform follow-up testing of that unit using a long-term test. Testing should be done over as much of the year as possible, including winter months when doors and windows are likely to be closed. If that result of the long-term test is 4.0 pCi/L or higher, the radon in the building should be lowered.
- If the initial test result is 8.0 pCi/L or higher, conduct a second short-term test and average its result with the initial short-term test result. If the average result of the two short-term tests is 4.0 pCi/L or higher, radon in the building should be lowered.
- A large difference in the results of the short-term tests may suggest a flaw in the testing process. Investigate and consider retesting. In situations where one of the test

results is 4.0 pCi/L or higher, repeat the test if the higher result is two or more times the lower result.

Perform a follow-up test in every unit that had initial test results of 4.0 pCi/L or higher.

For follow-up testing, devices should be placed in the same locations and under the same conditions as the initial test (as much as possible). This includes similar seasonal conditions and especially HVAC system operation. If using **short-term** tests for follow-up, be sure to maintain closed-building conditions. This ensures the two results are as comparable as possible.

The higher the initial short-term test result, the more certain you can be that you should follow up with a second short-term test rather than a long-term test. In general, the higher the initial measurement, the greater the urgency to do a follow-up test. For example, if the initial short-term measurement for a unit or area is several times the radon action level (for example, 8.0 pCi/L or higher), immediately perform a short-term follow-up test.

How are results interpreted?

See the "Interpreting initial results" section on page 32 for detailed information and instructions on analyzing test results. There is also a more detailed description of how the duplicate, blank and spike detectors are used to confirm that all devices are working properly.

- If the follow-up test is short-term, average the results of the initial test and the follow-up. If the average of the two tests is 4.0 pCi/L or higher, EPA recommends reducing the radon concentration in that building to below 4.0 pCi/L.
- If the follow-up test is long-term and the result is 4.0 pCi/L or higher, EPA recommends reducing the radon concentration in that building to below 4.0 pCi/L.

Multifamily building owners or property managers should not use a single short-term test to decide whether to reduce radon levels before consulting with a certified radon professional. Conduct a follow-up test to confirm the initial short-term measurement of 4.0 pCi/L or higher before deciding. EPA studies have shown that the average of two short-term measurements reduces the possibility of errors in the average radon concentration.

Is mitigation needed?

Mitigation is designing and carrying out a radon reduction strategy. The need to mitigate will depend on radon levels found by follow-up tests, if needed.

Oregon does not regulate or license radon mitigation professionals. The Oregon Radon

Awareness Program does have a list of companies with at least one radon measurement technician on staff who is certified by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). This list is for informational purposes only. It is not an endorsement by the Oregon Health Authority of any radon testing company.

That list is located at https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/HEALTHYNEIGHBORHOODS/RADONGAS/Pages/mitigation.aspx.

Current lists of certified mitigation technicians by these two national, non- governmental organizations can be found at www.nrpp.info and www.nrsb.org.

Your radon professional may perform more testing and make recommendations for radon mitigation. This often involves finding where radon is entering and deciding the best technique to fix it.

Both the U.S. EPA and OHA strongly suggest buildings with follow-up test results of above 4.0 pCi/L be mitigated. Very high radon concentrations and site-specific issues may suggest a quicker response.

What are the types of mitigation systems?

Multifamily buildings are more complex than single family homes, but one basic principle is the same: it is easier to keep radon out of the building than to remove it after it has entered.

Radon entry can be controlled with the following techniques:

- **Heating, ventilation and air conditioning (HVAC) systems**
  Adjusting the HVAC systems connected to a unit may reduce radon levels to below EPA's action level guideline of 4.0 pCi/L.
- **Soil depressurization**
  A suction fan is used to reduce the gas pressure in soil under the building slab. This lowered pressure prevents radon entry by venting the gas outside before it can be drawn into the building.
- **Building pressurization**
  Controlling indoor pressure relationships can prevent radon entry. In this case, by adding a fan that brings fresh outdoor air inside the building. When more outdoor air is brought in than is exhausted to the outside, the building becomes slightly pressurized compared to outside the building and the soil under the building.
- **Sealing entry routes**
  Seals are installed at major entry routes, such as sump pumps, utility entry points and HVAC systems to minimize radon entry.
- **Zone-specific ventilation**

A building's crawlspaces, tunnels, conduits, vaults, etc. may be used to design a system that reduces its high radon.

For new multifamily buildings, a cost-effective method to control radon is radon-resistant new construction (RRNC). Because a building's potential for elevated radon cannot be measured before it is constructed, specific components of a radon mitigation system (such as gravel layers and ventilation pipes) are installed while the building is under construction.

If testing reveals high radon in the finished building, a radon fan can easily be added. Under current statute, RRNC is required in all multifamily buildings and residences built after April 1, 2013, in seven Oregon counties (Baker, Clackamas, Hood River, Multnomah, Polk, Washington and Yamhill).

For existing buildings, the most effective and common radon reduction technique is adjusting the building's HVAC system. This method influences radon entry by reducing the pressure differences between the building's interior and the radon in the soil. Depending on the system type, operation and maintenance, an HVAC system can create positive or negative air pressure. Positive pressure can prevent radon entry, while negative pressure increases radon entry. A system can create positive pressure through additional heating, cooling and/or dehumidification. Proper HVAC maintenance and repairs can be an important tool in lowering radon levels.

Sometimes these adjustments can reduce the effectiveness of the HVAC system and increase operating costs. A professional analysis considers if ongoing operational costs would be greater than the upfront costs of active soil depressurization (ASD).

ASD is especially effective for buildings with higher levels of radon. Also, if adjusting the building's HVAC system does not lower a building or unit's radon, ASD is a common radon reduction method. ASD creates lower pressure in the soil that reverses the flow of air through a building's foundation and reduces radon entry.

In ASD, a series of pipes draw radon gas from underlying soil. A high suction fan attached to these pipes vents the soil gas from beneath the building. ASD includes sealing radon entry routes, which makes radon removal more efficient and reduces energy costs. When properly installed and maintained, ASD has no effect on general air quality within the building.

Radon typically enters the building from the soil through cracks and openings in the slabs and sub-structure. However, it is nearly impossible to seal every crack and penetration. Therefore, sealing radon entry routes is often used in combination with other mitigation techniques. It is not considered a long-term solution by itself.

Planning, costs and economies of scale in multifamily building radon testing

It is important to consider the costs associated with radon testing (labor, test kit costs, shipping, etc.) and what is at stake in human health. Multifamily building owners and managers should consider the two important points below:

- **Planning is critical**. Testing buildings for elevated radon is not difficult, but it requires coordination and planning. With so many moving parts, especially the quality assurance steps, multifamily building radon testing teams should have a well-thought-out testing plan that accounts for shipping times, time of the year and lab schedules. Poorly planned testing can lead to inaccurate results and extra costs.
- By planning it out on paper, owners and managers can identify timelines, costs (staff time and test kit costs) and possible problems. Knowing this information before testing begins will result in more accurate test results and lower costs.

OHA recommends multifamily building radon testing teams use the Test Kit Location Floor Plan and Test Kit Placement Log tools found in Appendix B: Step-by-step Guide for Planning Radon Testing in Oregon Multifamily Buildings.

Quality assurance

Mitigation can be expensive, so accurate radon test results are important. OHA strongly recommends that all radon testing include quality assurance (QA) measurements to make sure the results are reliable. Quality assurance requires more test kits to use as duplicates, blanks and spikes. These are explained in detail later. The three most important concepts in quality assurance are precision, accuracy and bias.

"Precision" is how close two or more measurements are to each other. In radon testing, we place two fully operating test kits side by side and label one as a "duplicate." Then we compare the measurements of each kit.

Small differences between the test kit and the "duplicate" are expected, but large differences may suggest a problem with the testing process.

"Accuracy" is how close the measured value is to the actual value. We want to make sure test kits on the site aren't measuring anything other than the radon. In radon testing, test kits called "blanks" are used to determine if manufacturing, shipping, storage or processing has affected the accuracy of the tests.

"Bias" is the amount of random error that is part of the testing process. Bias can include test kit defects and the quality of work at the testing lab. Test kits called "spikes" are used to check for bias.

Types of test kits for quality assurance

1. **Duplicates** tell us about the precision of our test results. Duplicates are normally-operating test kits placed next to the official test kits. We label these as duplicates and keep them in place for the same testing period.

   The number of duplicates should be 10 percent of the units tested. For example, if a building has 55 units to be tested, ten percent is 5.5. This number should be rounded up to 6 duplicate test kits. There must be at least one duplicate per building.

2. **Blanks** tell us about the accuracy of our testing kits and process. Blanks are also normally-operating test kits that are not open to the indoor air during the test period. Blanks help us determine if the manufacturing, shipping, storage or processing of the test kit affected its accuracy. They are called "blanks" because they are opened and placed next to other opened detectors but then immediately resealed. Because they are resealed, the blanks' results should be close to 0.0 pCi/L.

The number of blanks should be five percent of the rooms to be tested at the multifamily building. Again, you should round up if this number is a fraction. There must be at least one blank per building.

3. **Spikes** tell us if there are any problems with the testing plan. Spikes show how accurately the kits measure radon and how accurately the lab processes the test result. We call these kits "spikes" because they have been previously exposed to radon and should have "spiked" or higher readings when the lab evaluates them.

   The number of spikes should be three percent of the units to be tested. Once again, round up if this number is a fraction. It is recommended that owners and managers develop a test kit placement and floor plan for each multifamily building they will test. The serial numbers and locations of devices (including duplicate, blanks and spikes) should be included in the device log.

Quality assurance procedures for a multifamily building radon testing program

Please read this entire section before starting testing. Some steps are time- sensitive. All steps should be part of well-planned testing effort (9).

1. Multifamily building radon testing plans should calculate how many detector kits you need. This number equals:
   - The number of ground floor units
   - 10 percent of the number of units on each upper floor, and
   - Areas above stairwells or other shared air or common spaces.
2. In addition to unit and common area kits, you also need kits for quality assurance (QA). Specifically, you will need the following:
   - Duplicate kits (10 percent of the total number of units to be tested)
   - Blank kits (5 percent of the total number of units to be tested), and
   - Spike kits (3 percent of the total number of units to be tested).

   Note: Each tested building should have a minimum of one duplicate and one blank.

Important: Test kit percentages for QA are based on the number of units tested, not the number of detector kits.

3. After determining the number of test kits (detectors, blanks, duplicates and spikes) you need for the initial test, purchase kits from one manufacturer (and from one lot). It is most cost-effective to purchase in bulk.

4. Once you receive the kits, team staff should randomly pick the kits needed for spiking (3 percent of the total) from the boxes. Record the serial numbers of these kits, note them as kits being reserved for spike testing and set aside.

5. For radon measurements of a single multifamily building site, do the following:

    a. Approximately two weeks before testing starts, your radon team should contact a certified performance test chamber to discuss spiking services (http://aarst-nrpp.com/wp/test-chambers/). Most importantly, ask about and understand the chamber's schedule for spiking the kits and express mailing them back to you. Your testing timeline may depend on that schedule.

    b. Send the selected kits to the certified performance test chamber for spiking. The chamber should return the spiked kits to your team by overnight delivery so they arrive at the end of your testing period. Spikes can then be included in the same container as the detectors, blanks and duplicate kits and shipped overnight to the radon testing lab. This process ensures the lab can't identify the spike kits and helps keep your test free of bias.

6. For radon measurements of multiple multifamily buildings, do the following:

    a. Approximately a month before testing starts, your radon team should contact a certified performance test chamber (http://aarst-nrpp.com/wp/test-chambers/) to discuss the chamber's spiking schedule. Arrange spiking services and overnight return to you as each project finishes.

    b. With spiking service arrangements in place, the team should mail the kits picked for spiking (3 percent of the total) to the chamber. Now the team has a bank of kits at the chamber waiting to be spiked. At the team's request, the chamber will spike the requested number of banked kits with a known amount of radon and express mail them back to your team along with proper documentation.

7. In two to four weeks, the team will receive results for all the test kits analyzed. See "Interpreting initial results" on page 32 for how to analyze and apply the test results.

Radon testing process guide

The first step of initial radon testing is to map the layout and construction of the building, including areas where radon is most likely to enter.

1. Become familiar with radon testing methods and the building conditions needed for reliable testing.
2. Plan a practical testing strategy. Review the test steps and estimate the number of detectors you'll need. See pages 21, 22 and Appendix B.
3. Give radon testing information to residents. Give appropriate notice of radon testing (See Radon in Multifamily Buildings Risk Communication Toolkit).
4. Provide dates for placing and removing the test kits. Relate the importance of keeping proper test conditions. Stress that the test will help ensure resident safety and health, and interfering with the test kits could ruin the results.
5. Prepare a **Test Kit Placement Log** and a **Test Kit Location Floor Plan** for each building you plan to test. Use the building's emergency escape map as the floor plan.

   Record where you plan to place each test kit on both the Test Kit Placement Log and the Test Kit Location Floor Plan. See examples of these tools in Appendix B.
6. Test kits or testing services **must** meet the current requirements of the National Radon Proficiency Program (NRPP, www.nrpp.info) or the National Radon Safety Board (NRSB, www.nrsb.org). Testing **must** follow the directions on the test kit.
7. Determine the number of radon detectors you need for each floor. You need at least one detector kit for each ground floor unit. Some units may need more than one detector if they have areas or rooms that are lower than the rest of the unit. Also, you must test 10 percent of the units on each upper-level floor. See page 16 and Appendix B.
8. Add the test kits needed for quality assurance to this number. See the "Quality assurance procedures for multifamily building testing" section on pages 28-29.
9. Place test kits:
   - In all ground floor units
   - In any units above a basement, crawlspace or covered parking garage

- In upper floor units, as planned, and
- In laundry rooms and enclosed stair wells.

10. Place test kits in the appropriate location for each unit. See Appendix A for more information.

11. In addition to normally operating detectors, you will have additional test kits for quality control (duplicate, blank and spike measurements). See the "Quality assurance" section starting on page 28.

    Place the blank and duplicate kits using the "Test kit placement guide" in Appendix A.

    Spike test kits are not placed on site. They are used for quality assurance. You should receive spiked kits from the certified performance test chamber as close to the testing end date as possible. Detectors, duplicates, blanks and spikes must all be mailed to the radon testing lab at the same time.

12. Note the location and serial number of all test kits placed on site (detectors, duplicates and blanks) on the Test Kit Placement Log and Test Kit Location Floor Plan.

13. To get the best test results, complete short-term tests under **closed conditions**.

    Closed-building conditions: Close windows and doors for 12 hours before testing. Keep them closed except for normal entry and exit. Repair any structural or weatherization defects before testing. For more details, see the glossary.

14. **Conduct short-term tests during colder months** (October through March).

    Radon levels are highest during the coldest months when windows and doors are more likely to be closed and heating systems are often used. This usually results in less intake of outside air. **Do not conduct short-term tests** (between two and five days) **during severe storms or periods of high winds**. For more details, see the glossary.

15. Ensure HVAC systems are operating normally during test periods.

    - Air conditioning systems that recycle interior air may be operated.
    - Window air conditioning units may be operated in a re-circulating mode but must be more than 20 feet from any test kits.
    - Ceiling fans, portable humidifiers, dehumidifiers and air filters must be more than 20 feet from any test kits.
    - Portable window fans should be removed or sealed in place.
    - Fireplaces or combustion appliances (except water heaters and cooking

appliances) may not be used unless they are the primary source of heat for the building.

16. Document any radon mitigation systems already in place in the building. These systems should be operating during testing.

17. Do not conduct initial testing under the following conditions:

    - During abnormal weather or barometric conditions, storms or high winds. EPA studies show that barometric changes affect indoor radon concentrations.
    - During any construction that causes structural changes or renovations to the building, such as weatherization or replacement of the HVAC system.

Follow-up measurements

In units with initial short-term measurements of 4.0 pCi/L or higher, follow-up testing should start within one month after receiving the initial test results. Follow-up testing devices must be placed in the same locations. Short-term follow-up testing should be done in the same conditions as the initial test.

Follow-up testing using passive, short-term test kits should follow the same quality assurance procedures (the same percentage of duplicates, blanks and spikes). Follow the directions in Appendix A: Radon Test Placement Protocol Checklist and record test kit placement.

Interpreting initial test results

1. Review the results of the initial testing and highlight any results that are at or above 4.0 pCi/L.

2. For detector kits paired with duplicate kits, compare the results of the two kits by calculating the relative percent difference (RPD).

   Relative percent difference (RPD) = [(Initial result – duplicate result)/Average of both results] x 100%

If results are:	Expected range	In control	Warning	Out of control
2.0–3.9 pCi/L	0–25%	0–49%	50–67%	> 67%
≥ 4.0 pCi/L	0–14%	0–27%	28–36%	> 36%

   If a result over 4.0 pCi/L differs by 28 percent or more, the data quality should be questioned.

   In that case, call the radon testing lab to investigate the situation. You may need to

retest the unit, room or area associated with the questionable duplicate result. If the lab doesn't provide a satisfactory answer, someone from your team should discuss it with a radon testing professional.

3. Review the results of the blank test kits sent for analysis.

   Results should be very close to 0.0 pCi/L. If they are not, call the radon testing lab to investigate. If the lab does not resolve your concerns, someone from your team should contact a radon testing professional.

4. Check to be sure the spike results are accurate by calculating how close the measured value (the spike kit result) is to the reference value (the spike value reported by the certified performance test chamber). Calculate the relative percentage error (RPE) for each spike.

   Relative percentage error (RPE) = [(Measured value – reference value)/ Reference value] x 100%

   The result of each spike can then be put in one column or plotted on a chart.

How to use spike testing results

The purpose of spike testing is to make sure bias is not affecting a site's test results. One spike result outside the control limit does not mean that a building's test results are completely wrong. Instead, look for a trend (several or even a few areas with high results) in the RPE values in the percent difference column or table.

Relative percent error (RPE)	Expected range of variability	In control	Warning	Out of control
	Between +10% and -10%	Between +20% and -20%	Between +20% and -30%	Outside of +30% and -30%

Investigate any trend in RPE values in the warning zone.

In that case, review your team's storage, handling and kit placement plan and actions. At the same time, contact the radon testing lab and discuss the RPE results so the lab can review its own procedures. Someone from your team should contact a radon testing professional to discuss.

How to interpret follow-up test results

Repeat the same quality assurance calculations you did for initial testing.

Radon testing professionals

If you have questions about the quality assurance discrepancies listed above, ask a radon measurement professional.

Oregon does not regulate or license radon measurement professionals. The Oregon Radon Awareness Program has a list of companies with at least one radon measurement technician on staff who is certified by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). That list is located at https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/HEALTHYNEIGHBORHOODS/RADONGAS/Pages/measurement.aspx.

Current lists of measurement technicians certified by these two national, non-governmental organizations can be found at their websites, www.nrpp.info and www.nrsb.org.

This list is for informational purposes only and is not an endorsement by the Oregon Health Authority of any measurement company. These organizations are not the only sources of radon services.

After receiving follow-up results

The EPA, OHA Oregon Radon Awareness Program and numerous non-governmental groups recommend multifamily building owners take action to reduce radon level in units where:

- The average of the initial and follow-up short-term test results is 4.0 pCi/L or more, or
- The result of the long-term follow-up test is 4.0 pCi/L or more.

The OHA Oregon Radon Awareness Program also recommends multifamily building owners repair or adjust the building's HVAC system and then retest. If this doesn't reduce the radon below 4.0 pCi/L, owners can hire a radon mitigation professional to reduce the radon levels.

When should retesting be done?

As buildings age and the ground beneath them settles, radon entry may increase due to cracks in the foundation. Retesting is recommended every 5 years.

Retesting is also strongly recommended if:

- There are any major changes to the structure or weatherization of the building
- There are any major changes to the building's HVAC system
- Any rooms, areas of units or common areas not previously in use are put into use, or
- There is an earthquake in the area.

Please direct questions to:

Oregon Radon Awareness Program
971-673-0440
radon.program@dhsoha.state.or.us
www.healthoregon.org/radon

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Websites

Multifamily building owners, property managers and tenants may be interested in more information on radon. The Oregon Radon Awareness Program suggests the following radon websites:

- American Lung Association's National Radon Action Plan: https://www.lung.org/getmedia/450d2efd-2be4-4c6f-b12d-3aa516eeca3d/national-radon-action-plan.pdf
- Centers for Disease Control and Prevention, National Environmental Public Health Tracking Program: https://www.cdc.gov/nceh/tracking/topics/RadonTesting.htm
- Centers for Disease Control and Prevention (CDC), Protect Yourself and Your Family from Radon: https://www.cdc.gov/nceh/features/protect-home-radon/
- Environmental Protection Agency (EPA): www.epa.gov/radon
- The Navajo Nation Radon Program: https://www.epa.gov/indoor-air-quality-iaq/navajo-nation-radon-program
- National Radon Program services: www.sosradon.org
- This EPA-funded program is a nationally recognized leader in radon education. National Cancer Institute's radon page: https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/radon/radon-fact-sheet
- Oregon Health Authority's Oregon Radon Awareness Program: www.healthoregon.org/radon
- National Radon Proficiency Program: www.nrpp.info
- National Radon Safety Board (NRSB): https://www.nrsb.org/

Glossary

Action level: The radon concentration level at which consumers should take action to reduce radon levels.

Blanks: Blanks are radon test kits that are not exposed to room air. They are used to determine whether the test kits were contaminated during storage. When placing test kits, open and immediately re-sealed blanks to keep room air out of the test kit. While radon cannot travel through the plastic and enter the charcoal during storage, humidity in the storage area may get through tiny leaks in the packaging. Moisture in the charcoal can reduce the effectiveness of the test kits.

Carcinogen: A toxic substance that is directly involved in causing cancer.

Closed-building conditions:

Short-term tests should take place under the following conditions:

- Keep all windows and doors closed except for normal entry and exit.
- Run the HVAC system normally.
- Do not run fans or machines that bring in outside air during testing. Only allow fans that are part of a radon reduction system or small exhaust fans that operate for short periods.

When closed conditions are not maintained during testing, outdoor air may dilute the radon gas present. This can cause results to be lower than the true radon level. Verify that closed conditions were maintained when placing and picking up the test kits.

Also, check and document local weather forecasts prior to placing test kits. Do not do short-term tests (between two and five days) during severe storms or periods of high winds. The definition of "severe storm" by the National Weather Service is one that generates winds of 58 MPH or three-quarter inch diameter hail and may produce tornadoes.

Duplicates: Normally-operating radon detectors placed directly next to other normally-operating radon detectors. Duplicates show the precision of test results. Large precision errors may be caused by:

- Problems with the kit manufacture process, or
- Improper data recording or mishandling by suppliers, labs or testing personnel.

Precision error can be an important part of the overall error. The precision of duplicate measurements is monitored and recorded for quality assurance.

Long-term test: A radon testing kit designed for a long testing period, usually over 90 days.

Mitigation: The process of reducing radon in a home, multifamily building, school or business.

Picocuries per liter (pCi/L): A unit of measurement. It specifies the decay of radon in seconds in one liter of air.

Quality assurance: An integrated system of activities that ensure the testing process meets defined quality standards. Quality assurance activities involve planning, quality control, quality assessment, reporting and quality improvement.

Radon: A harmful gaseous radioactive decay product of radium.

Radon professional: A person, company or organization certified by either the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB).

Radon testing team: Assigned building management or personnel and certified radon professionals hired to conduct radon testing and/or mitigation.

Short-term test: A radon testing kit designed for a short testing period from two to 90 days.

Spikes: Detectors used to test the accuracy of a lab analysis or how accurately detectors measure radon. Spikes are test kits that have been exposed to a known concentration of radon in a chamber approved by the National Radon Proficiency Program (NRPP) or National Radon Safety Board (NRSB). See Appendix A: Radon Test Placement Protocol Checklist for more details about this process.

Appendix A: Radon Test Placement Protocol Checklist

This document is to help multifamily building owners and property managers conduct radon measurements in multifamily buildings. The steps below will help owners and managers decide where to test, how many test kits they need, where to place test kits and how to document the process. This document is a general guideline, not a mandate. Each building will present a unique situation. If you have specific questions or issues while testing your building, contact the Oregon Radon Awareness Program at 971-673-0440 or email radon.program@dhsoha.state.or.us.

Important: Order all radon test kits for the initial test at the same time. Kits should all be from the same manufacturing batch.

Test kit placement guide

Once you determine the number of test kits, they need to be placed in the units and common areas. See the "What rooms or units should be tested?" section on page 18.

1. Be sure to check these items before placing the radon test kits:
   - ❑ Closed building conditions have been maintained in the building for 12 hours.
   - ❑ The HVAC system is operating as it normally would when residents and staff are present.
   - ❑ Testing is being done during normal weather conditions.
2. As detectors are placed in the rooms, record the serial number, date and time opened and the location of each test kit on the Test Kit Placement Log and floor plan (see examples in Appendix B).

   Protocol for all test kits include the following. Be sure that each detector is:
   - ❑ In a location where it will be undisturbed
   - ❑ Out of direct sunlight
   - ❑ Three feet from all doors and windows
   - ❑ Four inches from all other objects
   - ❑ At least one foot from all exterior walls

- ❑ Between 20 inches and 6 feet from the floor
- ❑ Out of direct air flow from vents, and
- ❑ Four feet from the heat source.

3. Specific protocol for duplicate kits

   If the test kit you are placing is a duplicate, also be sure to:

   - ❑ Place the duplicate (side-by-side) test kit four to five inches away from the main test kit for that room.

4. Specific protocol for blank kits

   If the test kit you are placing is a blank, also be sure to:

   - ❑ Unwrap and open the blank, then immediately close and reseal it.
   - ❑ Place the blank test kit four to five inches away from the detector kit(s) for the room.

5. Specific protocol for spiked test kits

   - ❑ Arrange for the certified performance test chamber to return the spiked test kits to the testing team as close as possible to the day the kits are retrieved from the building. See the "Quality assurance procedures for a multifamily building radon testing program" section on page 28.

6. Testing period

   The test kits should be left out for at least 48 hours but no more than seven days. Four days is best. Follow manufacturer's instructions for your test kits.

   Retrieving kits

   Once the testing period is over, all test kits placed in the building (detectors, duplicates and blanks) must be retrieved. All detectors should be retrieved on the same date. Complete the data sheet when you retrieve detectors.

   - ❑ Record the ending date and time that the kits were picked up on the Test Kit Placement Log (Appendix B).
   - ❑ Record ending information on the test kit package (if needed).

7. Prepare and mail all kits

   - ❑ Follow the manufacturer's instructions to seal and prepare the test kits to be mailed to the lab.

- ❑ Include the spiked kits in the same box(es) as other kit types. Do not identify them as spiked kits.
- ❑ Mail all test kits (detectors, duplicates, blanks and spikes) to the radon testing lab listed on the test kit. Use a mail service that guarantees delivery to the lab within two days, but preferably overnight.

Appendix B: Step-by-step Guide for Planning Radon Testing in Oregon Multifamily Buildings

Below is a step-by-step guide for planning radon testing at a specific multifamily building site. It should be used with the other information in this document.

By preparing a "dry-run" on paper, owners and managers can identify timelines, costs (staff time and test kit costs) and unexpected barriers. Careful planning before testing begins will help ensure more accurate test results and lower costs.

1. **Prepare with proper planning.**

   To plan radon testing, you must understand the testing process and what steps to take to make sure test results are precise, accurate and free of bias.

   Review the test steps and find out if any residents have conducted their own radon tests. If so, collect and record their test results with as much information as possible.

   Make sure all units and common areas on the building floor plan are individually labeled; create labels for them if they are not.

   Become familiar with radon mitigation techniques that might be recommended.

2. **Communicate with residents and staff before testing.**

   It is important to notify residents before testing and inform them about what they can expect during the testing process. Specifically, building owners and managers should plan to:

   - Post sufficient notice of inspection for radon testing. Plan to give two weeks' notice before testing begins.
   - Provide the dates the detectors will be placed and retrieved.
   - Relate the importance of maintaining the proper test conditions.
   - Stress that testing is done to ensure resident safety and interfering with the testing devices could ruin the test results.
   - Tell residents when the test results will be available and how they can see the results. Let residents know they can learn more about radon from the EPA's "A Citizen's Guide to Radon" document at https://www.epa.gov/radon/citizens-guide-radon-guide-protecting-yourself-and-your-family-radon

This kit contains:

- Building signage for testing, and
- Templates for employee and resident notices and emails.

3. **Identify units, common areas and buildings to be tested**

Place a radon testing device in each ground-contact unit or apartment, room used as office space or room associated with the building complex. A unit is "ground-contact" if it has floors or walls in contact with the ground. Also place detectors in any ground floor units over crawl spaces, utility tunnels or enclosed parking garages.

Place testing devices in 10 percent of units on any upper floors, with a minimum of one device on each upper floor. On floors three and higher, place the test devices in units that are not directly above a unit being tested.

Test in the lowest level of a unit, even if it is not currently used, if it could serve as a den, playroom, office, work area or additional bedroom in the future. Test all non-residential ground-contact rooms or areas, such as utility, storage or mechanical rooms. Also test any other areas that:

- Could be occupiable with little or no modification
- Are occupied more than four hours a day, or
- Have air communication with occupiable areas, such as stairwells and elevator shafts.

Unoccupied areas containing radon can allow radon to enter apartments on upper floors. **If in doubt**, test. Make sure all units in the building floor plan are individually labeled; create labels for them if they are not.

Determine the number of test kits for upper floors as described below (see 4b.)

4. **Determine the number of normally-operating test kits needed.**

a. Count all ground-contact units, offices, laundry and recreational rooms and any other common areas.

Number of test kits for ground-contact units, rooms and offices:

_____

For common areas, use one test kit for every 2000 square feet. So, a lobby that is 3200 square feet would require a minimum of two detectors.

Area#1 square footage: _____
Number of kits needed: _____

Area#2 square footage: _____
Number of kits needed: _____

Area#3 square footage: _____
Number of kits needed: _____

Total test kits for all ground-contact units, rooms and areas:

_____

b. Determine the number of test kits needed for upper floors.

Calculate 10 percent of the total number of units on each floor and round up. So, a second floor with 16 units would require 1.6, which would round up to 2 test kits on each upper floor. There is always a minimum of one test kit per floor.

Number of units on floor 2: _____
Number of kits needed: _____

Number of units on floor 3: _____
Number of kits needed: _____

Number of units on floor 4: _____
Number of kits needed: _____

Total test kits for all upper floor units:

_____

5. **Determine the number of quality control test kits needed.**

a. Determine the number of **duplicate** test kits needed.

Units/areas to be tested x 0.10 (10%) = _____

Note: Round up to the next whole number. Remember, you need a minimum of one duplicate kit per building.

b. Determine the number of **blank** test kits needed.

Units/areas to be tested x 0.05 (5%) = _____

Note: Round up to the next whole number. Remember, you need a minimum of one blank kit per building.

c. Determine the number of **spike** test kits needed.

Units/areas to be tested x 0.03 (3%) = _____

Note: Round up to the next whole number.

6. **Determine total number of test kits needed to perform all required tasks.**

   _____ Number of normal test kits from section 4a.

   _____ Number of normal test kits from section 4b.

   _____ Number of duplicate test kits from section 5a.

   _____ Number of blank test kits from section 5b.

   _____ Number of spike test kits from section 5c.

   Total number of test kits for building: _____.

7. **Use a Test Kit Location Floor Plan to create a Test Kit Placement Log.**

   Multifamily building radon testing teams can use the building's emergency escape plan map to decide which units to place the different types of test kits in (detectors, blanks and duplicates). These documents guide the planning of a radon testing effort as well as the testing itself.

   Use the building floor plan (see example below) to create Test Kit Placement Logs (see examples on page 48 and page 49). These logs indicate where the detectors, duplicates and blanks will be placed.

   Important: Create a separate Test Kit Placement Log for each building at the multifamily building site.

Test Kit Placement Instructions

When planning the placement of the test kits and recording data when testing is taking place, it's recommended to use a system to record this information. We have provided examples of a Test Kit Placement Log (see page 48), and Test Kit Location Floor Plan (see page 49) to be used at your convenience.

Directions: using your building's Test Kit Placement Log, indicate the units or rooms that will have detectors (D), blanks (B) and duplicate (Dup) test kits in the unit comment column. Select these using the guidance in the "What rooms or units should be tested?" section on page 15 and the "Quality assurance procedures for a multifamily building radon testing program" section on page 28.

Although the Test Kit Placement Log examples has rows reserved for the 10 percent of rooms at each building site where duplicates should be placed and for the 5 percent of rooms where blanks should be placed, these are for your team's convenience. The selection of rooms for duplicates and blanks should be random. Remember, there must be a minimum of one duplicate and one blank per building.

The remaining fields in the log will be filled out when testing begins.

Regarding the remaining fields:

- "Test kit serial #" is the unique identification number found on each test kit.
- "Start date and time" and "Stop date and time" refer to the actual moments when kits are placed and activated to begin measuring the radon in the room (and then stopped). This information helps the lab adjust its equipment for the most accurate analysis of the test kit.

If you have questions, please contact the Oregon Radon Awareness Program at 971-673-0440 or radon.program@dhsoha.state.or.us.

www.healthoregon.org/radon

Test Kit Placement Log Example

Building name: Cedar Cove

Address: 3415 Cedar Dr

Portland, OR 97224

Contact email

Testing contractor: AAA Radon Testing

Contractor phone: 503-222-5555

Building contact: Patience Riley

Contact phone: 503-888-2997

Test kit serial #	Floor – unit #	Room	Place -location	Start date and time	Placement Tech	Stop date and time	Pick-up Tech	Comments
12345	1-100	Living	S Wall	2/3/20 11:20 am	ML	2/7/20 1:56 pm	JR	
12346	1-100	Bed	Dresser	2/3/20 11:23 am	ML	2/7/20 2:06 pm	JR	D
12347	1-104	Living	S Wall	2/3/20 11:30 am	ML	2/7/20 2:10 pm	JR	
12348	1-106	Living	S Wall	2/3/20 11:32 am	ML	2/7/20 2:16 pm	JR	
12349	1-106	Living	S Wall	2/3/20 11:34 am	ML	2/7/20 2:24 pm	JR	
12350	1-108	Bed	N Stand	2/3/20 11:40 am	ML	2/7/20 2:30 pm	JR	B
12351	1-110	Living	W Wall	2/3/20 11:45 am	ML	2/7/20 2:35 pm	JR	
12352	1-112	Living	W Wall	2/3/20 11:52 am	ML	2/7/20 2:41 pm	JR	
12353	1-114	Living	W Wall	2/3/20 11:59 am	ML	2/7/20 2:45 pm	JR	Kit moved
12354	1-116	Living	W Wall	2/3/20 12:04 pm	ML	2/7/20 2:49 pm	JR	
12356	2-200	Living	S Wall	2/3/20 11:20 am	GJ	2/7/20 2:02 pm	GJ	window open

Technician: Matt Laughlin **Initials:** ML **License number:** G100225

Technician: George Jackson **Initials:** GJ **License number:** G107809_

Technician: Julio Ramirez **Initials:** JR **License number:** G122349

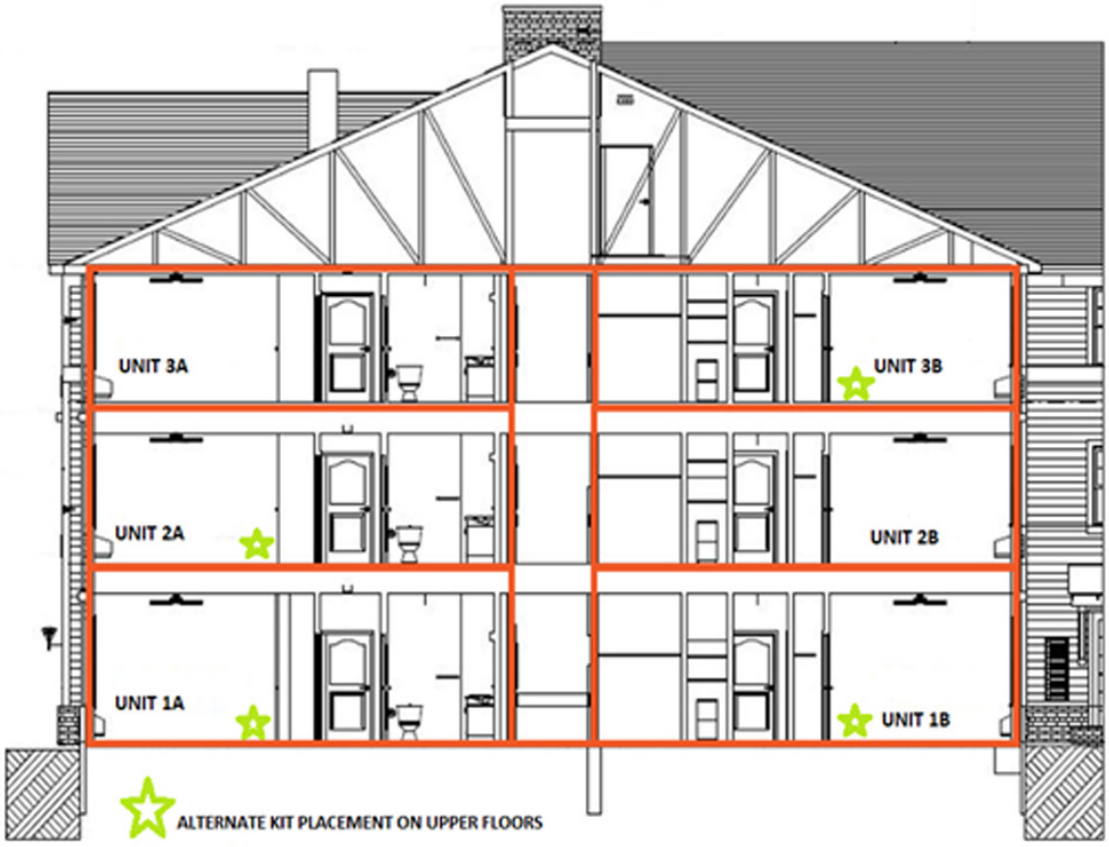
Test Kit Location Floor Plan Example

Building Floor Plan

Building Name: Cedar Cove

Building Address: 3415 Cedar Dr

Contact Person: Patience Riley



Test Kit Placement Log Template

Building name:

Address:

Testing contractor:

Contractor phone:

Building contact:

Contact phone:

Test kit serial #	Floor – unit #	Room	Place -location	Start date and time	Placement Tech	Stop date and time	Pick-up Tech	Comments

"D" = Duplicate **"B" = Blank** **"S" = Spike**

Technician: _____ **Initials:** _____ **License number:** _____

Technician: _____ **Initials:** _____ **License number:** _____

Technician: _____ **Initials:** _____ **License number:** _____

Technician: _____ **Initials:** _____ **License number:** _____

Test Kit Location Floor Plan Template

Building Floor Plan

Building Name: _____

Building Address: _____

Oregon Health Authority
PUBLIC HEALTH DIVISION
Phone: 971-673-0440

You can get this document in other languages, large print, braille or a format you prefer. Contact Oregon Radon Awareness Program at 971-673-0440 or email radon.program@dhsoha.state.or.us. We accept all relay calls or you can dial 711.

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