Testing for Elevated Radon in Oregon Schools

Replaced with photo of Oregon school in final version

DRAFT of 4-13-2016

A Protocol and Plan

The purpose of this document is to provide Oregon school districts with a protocol to accurately test for elevated radon levels in school buildings, per Oregon Revised Statute (ORS) 332.166-167.

NOTICE

This protocol was prepared as a compilation of work produced by the Oregon Health Authority and funded by a grant from the United States Environmental Protection Agency Region 10 Radon Program. Neither the Oregon Health Authority, United States Environmental Protection Agency, nor any affiliated organization, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the Oregon Health Authority, United States Environmental Protection Agency, nor any affiliated organization.

ACKNOWLEDGMENT

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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 of decreasing radon's harm. It is important to recognize that school buildings are the second leading source of radon exposure for students and school employees.

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

The 2015 Legislature passed House Bill (HB) 2931so that elevated radon levels in Oregon schools would be known. HB 2931later became Oregon Revised Statute (ORS) 332.166-167. Oregon Health Authority, as directed by ORS 332.166-167, produced this guide to assist Oregon school districts to accurately measure their school buildings for elevated radon. As directed by the statute, this guide follows current national guidelines for measuring radon in schools and large buildings (ANSI/AARST, 2014). It is based on radon school measurement plans from other states.

Under the statute, school districts are to submit a plan to Oregon Health Authority by September 1, 2016. OHA recommends, but does not require, that a plan for testing each school site be created before testing begins.

Per ORS 332.166-167, actual testing of schools must be done on or before January 1, 2021 and the testing results sent to OHA and posted on the school or school district's website. These requirements do not apply to schools that have been tested for elevated radon on or after January 1, 2006.

In this protocol's appendices are tools and step-by-step instructions to help schools 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

Testing for Elevated Radon in Oregon Schools

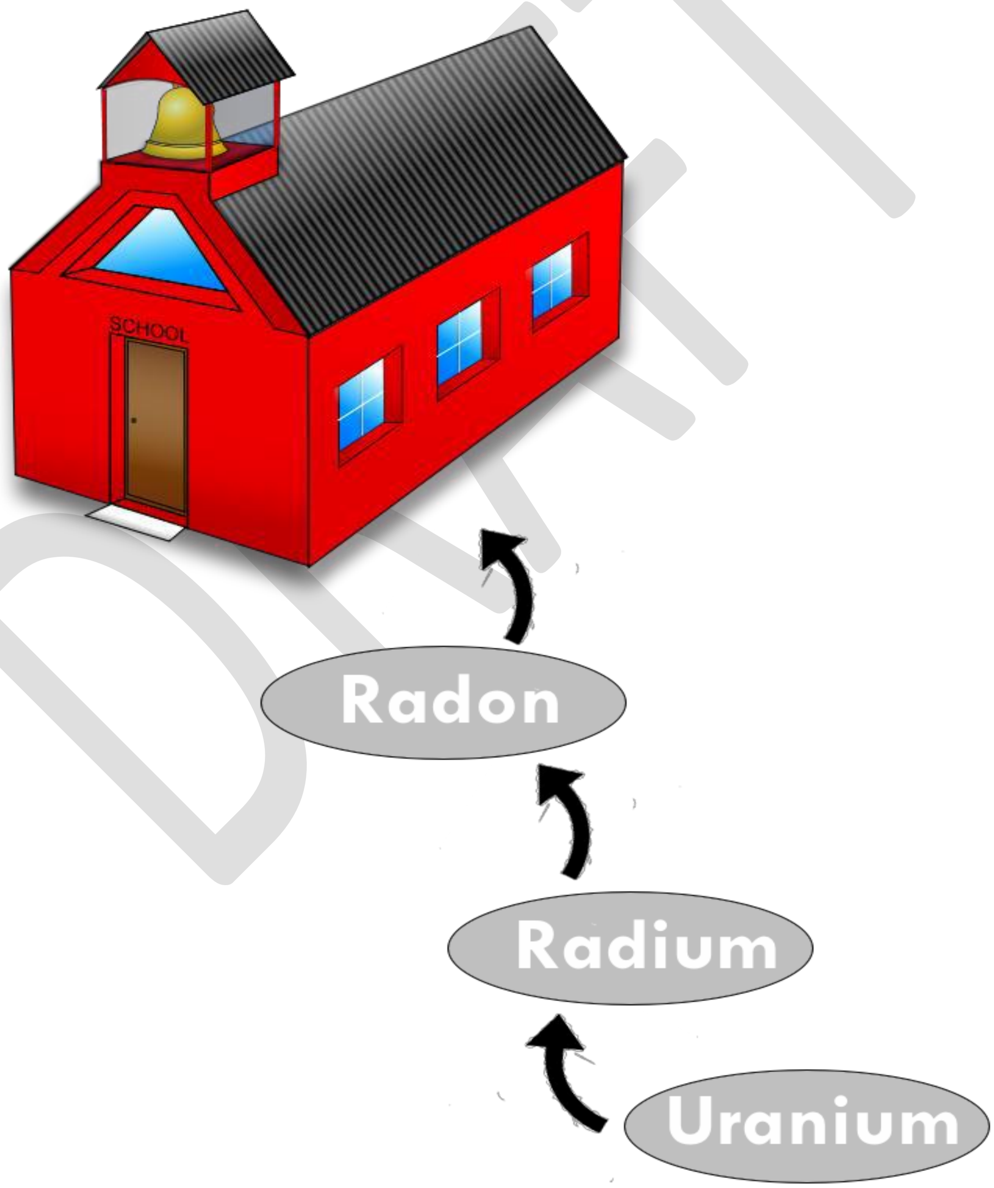
GUIDE OBJECTIVES

This guide addresses learning objectives for radon screening measurements in schools. The objectives are for schools to:

1. Accurately carry out the testing of schools for elevated levels of radon, per ORS 332.166-167.
2. Define the elements and components of radon and radon measurement, using appropriate labels, terms and wording, as well as possessing the ability to communicate effectively such definitions to others.
3. Understand the relevant laws and elements of physical science to the radon measurement process, as well as understanding the role of physical science in both the introduction and presence of radon in the environment.
4. Forecast how radon occurs, when, where and why, as well as predict how this element will behave at different times, in different places and/or under different circumstances.
5. Measure relevant properties of radon, utilize appropriate scales of measurement, interpret both status and change, and interpret measurements' validly and reliably.
6. Utilize the standard devices and/or instrumentation approved for radon measurement, understand device calibration and servicing, and understand potential errors associated with the misuse or misplacement of such devices.
7. Model the required elements of quality control and quality assurance throughout the measurement process as a continuous part of the measurement protocol, and understand the inherent values of a quality controlled approach to measurement.
8. Comply with existing laws, regulations, and other established procedural requirements associated with radon measurement, as well as emulate the importance of legal oversight of radon-related activities.
9. Understand the processes associated with basic radon mitigation.

WHAT IS RADON?

Radon comes from natural deposits of uranium in the soil and is found everywhere in the world. Uranium naturally decays into radium which further breaks down into radon gas. While some geographic areas have more radon than others, the only way to determine a building's radon level is to test the building. Any building has the potential for elevated levels of radon. Because radon is a gas, it can move up through the soil allowing it to enter buildings in contact with the soil. Radon is typically at its highest concentration in the lower portion of a building. Once radon enters a building, it is easily dispersed through the air. It then begins a radioactive decay process that leads to the creation of radon decay products. Radon gas itself is relatively harmless until it produces these decay products. The decay products release damaging energy particles which can strike lung tissue and lead to lung tissue damage if inhaled.



WHY IS RADON A PROBLEM?

Radon is a naturally occurring colorless, odorless, tasteless and radioactive gas. Radon travels through the soil and enters buildings through cracks and openings in the foundation. This can occur in buildings or homes of any age and structural type (e.g. with or without basements). Eventually, radon decays into radioactive particles (decay products) that can be trapped in the lungs when you breathe. As these particles in turn decay further, they release small bursts of radiation. This radiation can damage lung tissue and lead to lung cancer over the course of a lifetime.

Radon is a human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. Like other environmental pollutants, there is uncertainty about the magnitude of radon health risk; however, scientists are more certain about risks from radon than from other cancer-causing environmental pollutants, such as the herbicide glyphosate or the flame retardant chemicals polybrominated biphenyls (PBBs). [See table below.] This is because estimates of radon risk are based on studies of cancer in humans (underground miners and other more current epidemiological studies).

The Surgeon General, in 2005, warned Americans about the health risk from exposure to radon in indoor air (US Surgeon General, 2005). Other health agencies, including the US Centers for Disease Control & Prevention and the World Health Organization have come to similar conclusions about radon's danger to human health. Because radon is the leading cause of lung cancer for non-smokers in the U.S. and breathing radon over prolonged periods can present a significant health risk, the Surgeon General urged Americans to perform radon testing.

Radon and Lung Cancer:

The US EPA ranks Radon in the highest classification of cancer causing substances – Group A. This category ONLY includes those substances that show sufficient evidence to cause cancer in humans.

EPA's Classification of Cancer Causing Agents:

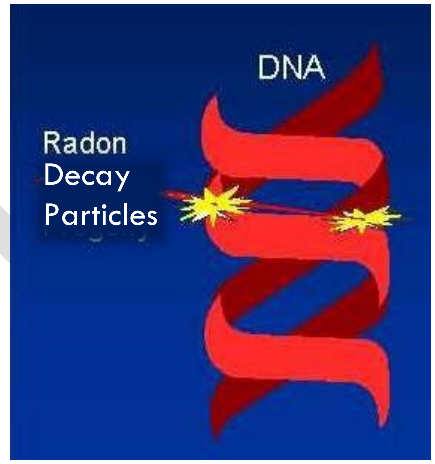
- Group A: Known human carcinogen (e.g. Radon)
- Group B: Probable carcinogenic (e.g. glyphosate; polybrominated biphenyls)
- Group C: Possibly carcinogenic
- Group D: Not classifiable (no data) and
- Group E: Evidence of non-carcinogenicity

How does Radon cause cancer?

Unlike radon, which is a gas, radon decay products are solid particles. These particles become suspended in the air when they are formed. Some of these particles "plate out" (attach to surfaces) and attach themselves to aerosols, dust, and smoke particles in the air. Inhaling these particles can deliver a radiation dose to the lungs that can damage your lung tissue and even affect your DNA.

DNA is the fundamental blueprint for all of the body's structures: The DNA blueprint is encoded in each single human cell. Each cell is continually reading various parts of its own DNA as it constructs fresh molecules to perform a variety of tasks.

The small decay particles exert energy (called ionizing radiation) on the lung tissue and cause damage. They can even strike and disrupt the cell DNA, which damages the cancer suppressant gene and increases the risk for contracting cancer. These collisions and ionization take place very quickly, but the biological effects (i.e. beginnings of cancer) take much longer to become known. Cancer is produced when the DNA code is altered in a way that leaves an error in the DNA blueprint. The probability (or risk) of lung cancer is based on how much you are exposed to and for how long. Scientific research indicates that at least a 10 to 20 year incubation period is required before lung cancer develops.



The USEPA estimates that 21,000 radon-related lung cancer deaths occur each year in the US. Below is a table of estimated US deaths from different cancer types in 2015. If radon-induced lung cancer were its own category (see table below), it would be our county's eighth leading cause of death from cancer.

(Siegel RL, CA: A Cancer Journal for Clinicians, 2015 & Field RW)

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

Another report of annual deaths from radon-induced lung cancer comes from the National Research Council. They estimate that 1 in 10 or 1 in 7 (depending on risk model) of all lung-cancer deaths—ranging from 15,400 or 21,800 per year in the United States—can be attributed to radon exposure. This range is made up of adding deaths from radon exposure among people who have smoked at least 100 cigarettes in their lives (ever-smokers) together with deaths attributable to radon among never-smokers (National Research Council, 1999).

Not everyone who breathes in radon (or radon decay products) will develop lung cancer. An individual's risk of lung cancer depends mostly on the concentration of radon, the duration of exposure (over a lifetime) and genetic and health disposition. 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.

Breathing radon does not cause any short-term human health symptoms such as shortness of breath, coughing, headaches, or fever. Children (who have higher respiration rates than adults) have been reported to have greater risk than adults for certain types of cancer from radiation, but there is no conclusive data at this time on whether children are at greater risk than adults from radon. There is no conclusive data at this time that radon exposure causes illnesses other than lung cancer.

HOW IS RADON REPORTED?

In the U.S, 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 IN SCHOOLS?

USEPA began investigating radon in schools in 1988. The initial studies show that there were elevated levels of radon in schools in every state.

A further study called the *National School Radon Survey* showed that 19.3% of all U.S. schools (nearly one in five) have at least one frequently occupied room with short-term radon levels above the **USEPA Action Level: (≥4.0 pCi/L)**. In total, USEPA estimates that there are over 70,000 schoolrooms that are impacted by radon (EPA 1993).

WHAT IS THE USEPA ACTION LEVEL?

USEPA recommends reducing the concentration of radon in indoor environments to below the Radon Action Level of 4.0 pCi/L. This "action level" is not health-based. No amount of radon is good for a person. For comparison, the World Health Organization's "action level" is 2.7 pCi/L. While the radon in most buildings can be lowered below 4.0 pCi/L, this may depend on the characteristics of the building and the ground underneath it.

Yet because outdoor levels of radon across the country average 0.4 pCi/L, it's not possible to reduce people's risk from radon exposure to zero. Again, the goal of radon reduction is harm reduction.

WHERE DO WE SPEND OUR TIME?

A study for the US EPA shows that we spend 87.9% of our time indoors on a daily basis (Klepeis, et al., 2001). Because many people, particularly children, spend much of their time at home, the home is likely to be the most significant source of radon exposure. US EPA reports that 1 in 15 homes in the United States are estimated to have elevated radon, which is above 4 pCi/L (EPA, 1992). Some areas of Oregon are found to have higher radon levels than others. But it is very possible that a home in an area considered to have low risk could have elevated radon levels. The opposite could also be true.

The only way to know whether a home has elevated radon levels is to test it.

For most school children and staff, the second largest contributor to radon exposure is likely to be their school. As a result both USEPA and the Oregon Health Authority (OHA) recommend that school buildings as well as homes be tested for radon. For schools in Oregon, this recommendation became law in the 2015 Legislature (ORS 332.166-167).

WHAT ARE THE ROUTES OF RADON ENTRY?

Many factors contribute to the entry of radon gas into a school building. Schools that are in the same community can have significantly different radon levels from one another. As a result, school officials cannot know if elevated levels of radon are present without testing.

Radon Levels in Buildings

The level of radon in a building depends on:

- The concentration of uranium and radium in the soil or underlying geology;
- How easily the radon can be transported into the building through the soil permeability, pathways and openings into the building;
- Air differentials e.g. the "stack effect" where warm indoor air leaving the upper parts of structure is naturally replaced by colder air that may contain radon gas (if at high concentrations in soil);
- How air is transported within a building;
- The ventilation rate of the building.

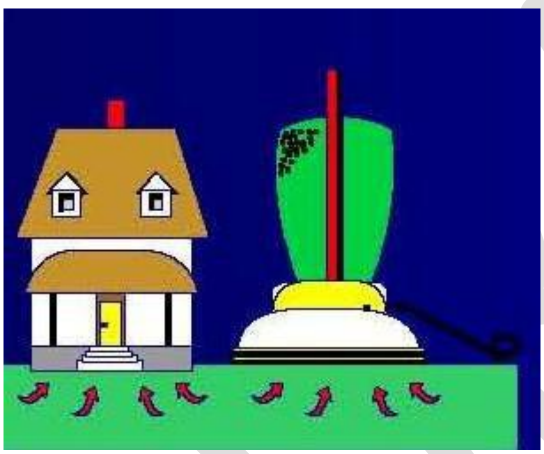
Entry through Pressure-Driven Transport

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

Radon transport through soil to building requires:

- A driving force – A force that draws or pushes the radon toward the building.
- A pathway to the home or building – High soil permeability, utility trenches, etc…
- Openings in the foundation – Joints, cracks, earthen areas, utility penetrations, etc…

Schools and large buildings usually operate with an inside air pressure that is lower than the surrounding soil. This allows air, including radon (if present) outside or underneath the building, to be sucked inside. The design and operation of mechanical ventilation systems may also depressurize the building and enhance radon entry.



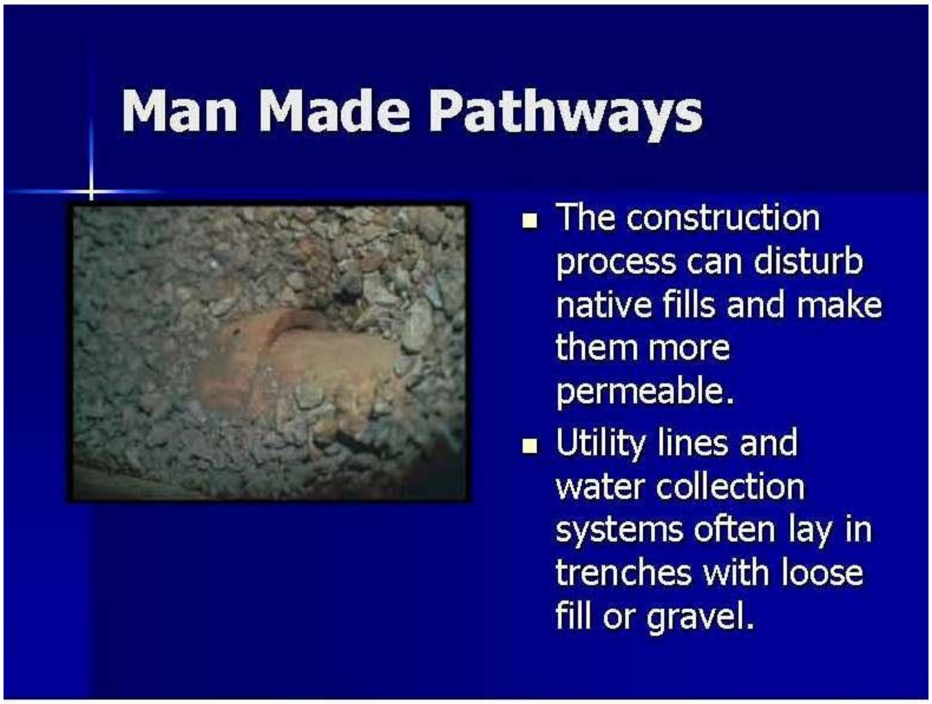
- Buildings can create vacuums that will draw in soil gas.
- These vacuums are very small and are referred to as air pressure differentials

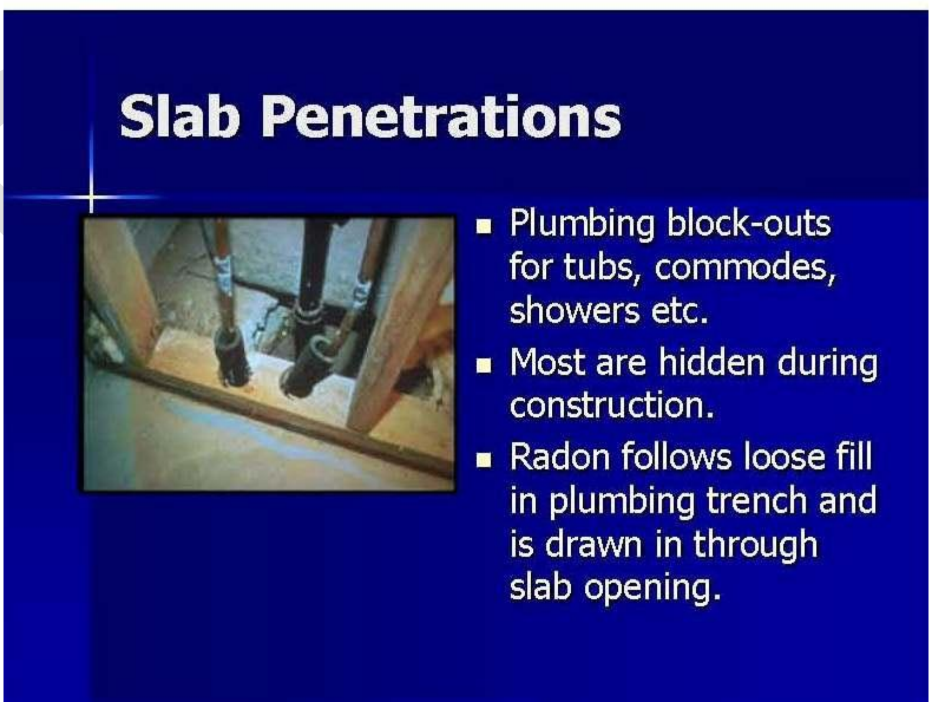
Entry through Diffusion

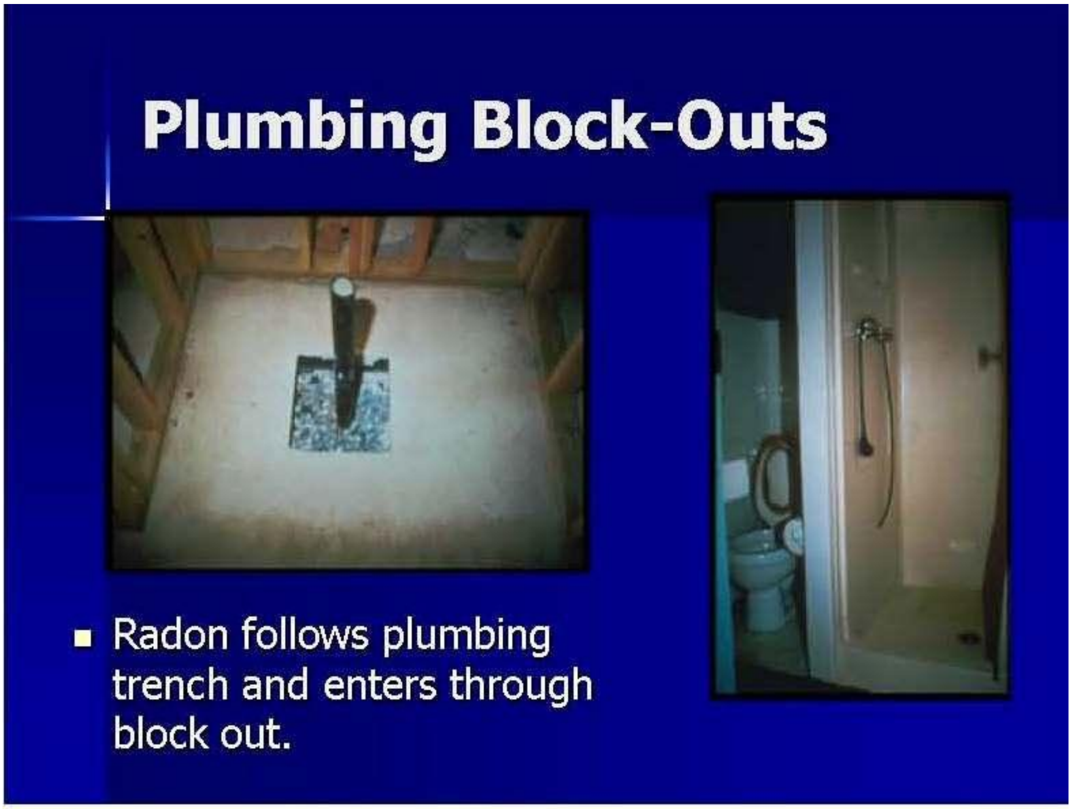
Radon also can enter buildings when there are no pressure differences. This type of radon movement is called diffusion-driven transport. Diffusion is the same mechanism that causes a drop of food coloring placed in a glass of water to spread through the entire glass. Diffusion-driven transport is rarely the cause of elevated radon levels in existing buildings. It is also highly unlikely that diffusion contributes significantly to elevated radon levels in schools and other large buildings. Many schools and large buildings are constructed on adjoining slab-on-grade construction, which allows radon gas to enter through the foundation and expansion joints between the slabs as well as cracks in the slabs themselves.

Entry through Other Mechanisms

Other features, such as the presence of a basement area, crawl spaces, utility tunnels, sub slab Heating, Ventilation & Air-conditioning (HVAC) ducts, sumps, drains, cracks, or other penetrations in the slab (e.g., around pipes) also provide areas for radon to enter indoor spaces.







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 that is supplied directly to a building and that is in contact with radium-bearing formations can be a source of radon in a building due to the off-gassing of radon when the water is brought inside. Extremely high levels of radon in well water will raise radon gas levels in buildings. For example, 10,000 pCi/L of radon in well water is expected to increase, by itself, the radon in a structure by 1.0 pCi/L. The majority of elevated radon in most buildings will come from the soil underneath, not the well water. To date, the only known health risk associated with exposure to radon in water is a result of the airborne radon that is released from the water when it is used. For more information on well water quality, contact the Oregon Domestic Well Safety Program at www.healthoregon.org/wells.

Entry through Building Materials

Radon can also emanate from building materials. However, this has rarely been found to be the cause of elevated levels in existing schools and other large buildings. Building materials, such as concrete, brick stones for fireplaces, granite and sheet rock may contain some radium and can be sources of indoor radon. The extent of the use of radium-contaminated building materials is unknown but is generally believed to be very minor.

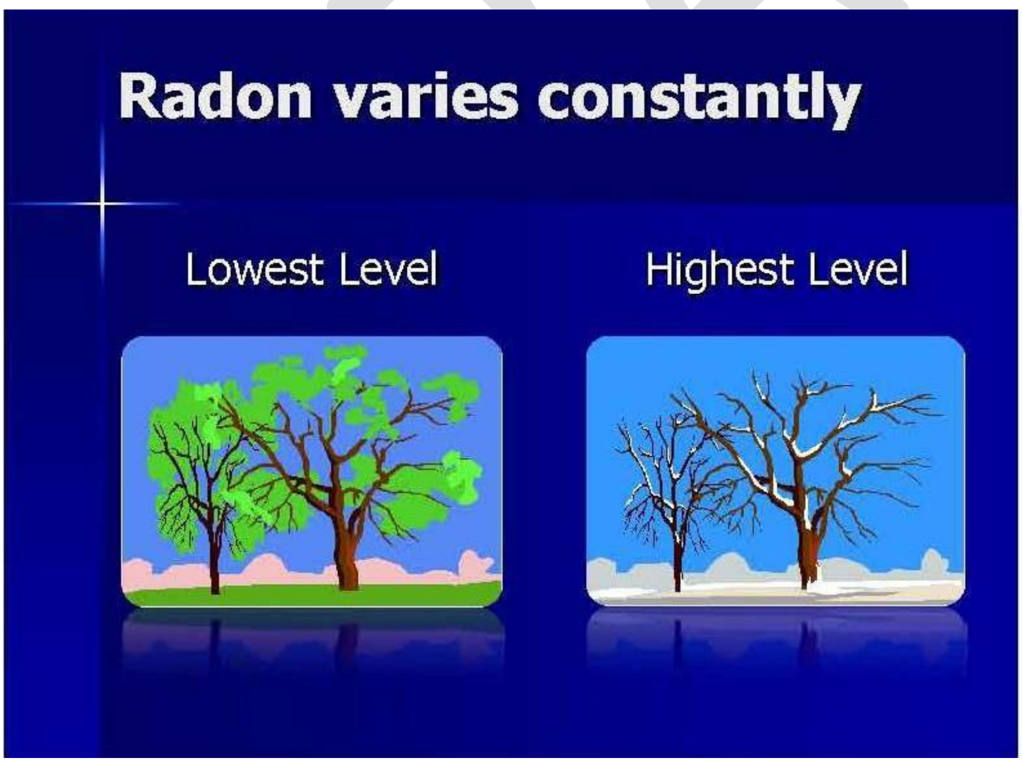
Entry through HVAC Systems

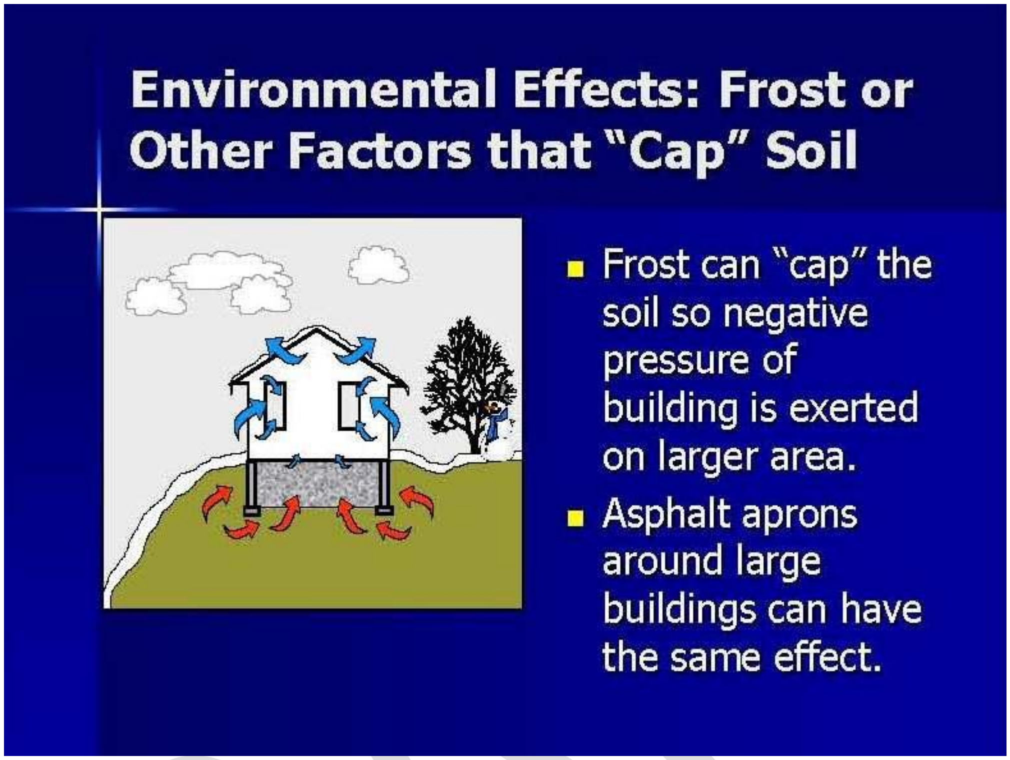
Depending on their design and operation, HVAC systems can influence radon levels in schools by: Increasing ventilation (diluting indoor radon concentrations with outdoor air); decreasing ventilation (allowing radon gas to build up); pressurizing a building (keeping radon out); or depressurizing a building (drawing radon inside). HVAC systems can transport radon from an area of high concentration to one of low concentration.

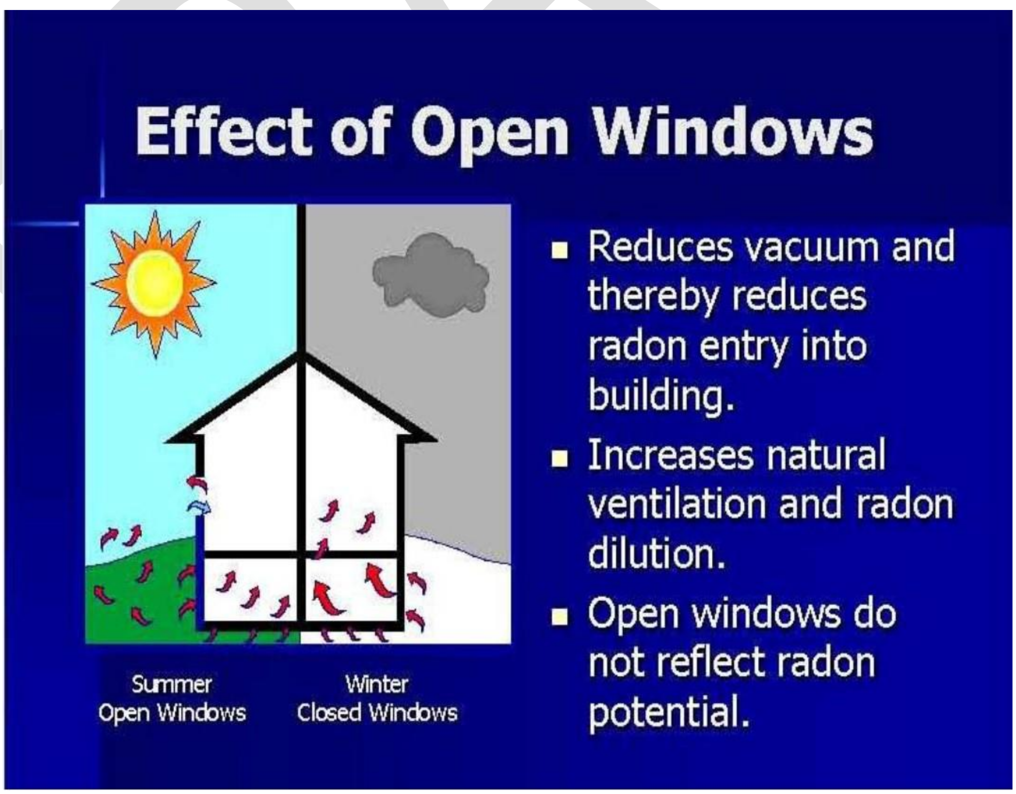
Overall indoor air quality concerns may interest schools, in general. Many schools have poor indoor air quality due in part from low rates of ventilation (low outdoor air intake). Poor air exchange can also increase concentration of common asthma triggers like mold and dust mites. The frequency and thoroughness of HVAC maintenance can also play an important role. For example, if air intake filters are not periodically cleaned and changed, this can significantly reduce the amount of outdoor air ventilating the indoor environment. Less ventilation allows radon to build-up indoors. An understanding of the design, operation and maintenance of a school's HVAC system and how it influences indoor air conditions is essential for understanding and managing a radon problem. [This is also true for other indoor air quality concerns in schools.]

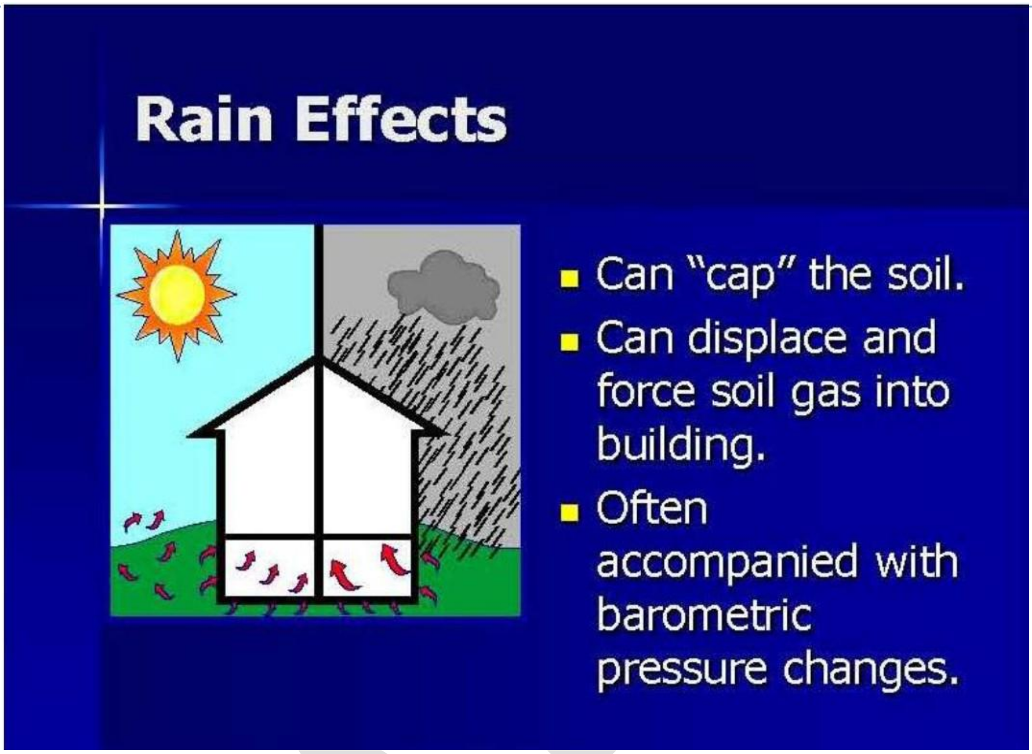
ENVIRONMENTAL FACTORS INFUENCING RADON CONCENTRATIONS

Seasonal and mechanical variations can affect radon concentrations. Radon levels vary constantly – daily and seasonally. In the summer, with windows and doors open and warmer temperatures, we would expect lower concentrations. During the warm months when buildings are either open or well ventilated through air conditioning, the indoor radon levels are largely determined by geologic rather than mechanical factors. Finally, room users can cause radon levels to increase by inadvertently blocking air returns, etc.




Environmental Effects: Frost or Other Factors that "Cap" Soil
Frost can "cap" the soil so negative pressure of building is exerted on larger area.
Asphalt aprons around large buildings can have the same effect.


Effect of Open Windows
Summer
Open Windows
Winter
Closed Windows
Reduces vacuum and thereby reduces radon entry into building.
Increases natural ventilation and radon dilution.
Open windows do not reflect radon potential.



What Rooms Should Be Tested?

EPA's research in schools has shown that radon levels in schools often vary greatly from room to room in the same building. A known radon measurement result for a given classroom cannot be used as an indicator of the radon level in adjacent rooms.

Therefore, per ORS 332.166-167, School Radon Measurement Teams (i.e. personnel appointed to measure a school site for elevated radon) must, at a minimum, conduct initial measurements in *all frequently occupied rooms in contact with the soil or located above a basement or a crawlspace*.

School Testing

- All frequently occupied rooms should be tested simultaneously.
- Examples include: offices, classrooms, conference rooms, gyms, auditoriums, cafeterias & break rooms.
- A minimum of one detector for every 2000 sq. ft. of open floor space or portion thereof is required.

USEPA studies indicate that radon levels on upper floors are not likely to exceed the levels found in ground-contact rooms. Testing rooms on the ground-contact floor or above unoccupied basements or crawlspaces is sufficient to determine if radon is a problem in a school. Areas such as rest rooms, hallways, stairwells, elevator shafts, utility closets, kitchens storage closets do not need to be tested (Note: these areas may be important areas for diagnostic testing if elevated radon is found).

TYPES OF RADON MEASUREMENT DEVICES

There are two main categories of radon test kits:

1. Passive – Do not require external power to make them work.
2. Active (continuous) – Require power to function (from batteries, DC adaptors, or electricity from the wall)

For school district testing, it is recommended that a passive device be used. Passive devices require no electrical power to perform their function. Passive devices are exposed to indoor air by being "uncapped" or similarly activated, then left in place for a length of time, known as the measurement period.

Active devices, on the other hand, require an electrical power source and are capable of charting radon gas concentration fluctuations throughout the course of a given measurement period (usually by producing integrated periodic measurements over a period of two or more days).

Passive Devices

Activated Charcoal Adsorption Devices (AC) are passive devices, and the charcoal within these devices has been treated to increase its ability to adsorb gases. The passive nature of the activated charcoal allows continual adsorption and desorption of radon. During the entire measurement period (typically two to seven days), the adsorbed radon undergoes radioactive decay.

As with all passive devices, the average concentration calculated is subject to error if the radon concentration in a room varies substantially during the measurement period. This device does not uniformly adsorb radon during the exposure period; as a result, these test kits are not true integrating devices. ACs must be promptly returned to the laboratory period using a mail service that guarantees delivery to the laboratory within two days at maximum, but **preferably overnight**. The potential for any radon gas in the envelope to "leak" out drives this urgency.

Different types of ACs are commercially available. A device commonly used contains charcoal packaged inside an air-permeable bag. Radon is able to diffuse into this bag where it can be adsorbed onto the charcoal. Another device is a circular container that is filled with activated charcoal. One side of the container is fitted with a screen that keeps the charcoal in but allows air to diffuse in the charcoal. For some of these devices, the charcoal container has a diffusion barrier over the opening to improve the uniformity of response to variations of radon concentration over time.

How AC kits work:

- Container is opened in the area to be sampled.
- Radon gas enters into the charcoal and remains trapped along with subsequent radon decay products.
- At the end of the sampling period, the container is sealed and sent to the lab for analysis.
- The lab counts the amount of decay from the radon adsorbed to the charcoal on a gamma detector, and a calculation based on calibration information is used to calculate the radon concentration.

AC detectors are deployed from 2 to 7 days, depending on design. Because charcoal allows continual adsorption AND desorption of radon, this method does not give a true integrated measurement over the exposure time. Use of a diffusion barrier (usually included in the test kit) over the charcoal reduces the effects of drafts and high humidity.

Advantages:

- Inexpensive
- Does not require power to operate
- Can be sent through the mail
- Can be deployed by anyone
- Accurate

Disadvantages:

- Should be analyzed by a laboratory as soon as possible after removal from building
- Highly sensitive to humidity
- No way to detect tampering
- Results biased towards last 24 hours of deployment period

Electret-Ion Chambers (EIC) are also passive devices. They function as true integrating detectors measuring the average radon gas concentration. EICs take advantage of the fact that radiation is emitted from the decay of radon and radon decay products impart an electrical charge on the airborne particles that are released. These charged particles or ions are attracted to an electro statically charged disc in the EIC chamber, which reacts to their presence by losing some of its charge. The amount of the reduction in charge is directly related to the average radon concentration in the chamber.

EICs may be designed to measure for short periods (typically two to seven days) or for longer periods, up to one year. The type of electret and chamber volume determine the usable measurement period. The electret is removed from the chamber and its voltage is measured with a specialized reader both before and after the measurement period. The difference between the two voltage readings is used to calculate the average radon concentration

How they work:

- The plunger at the top is used to open and close the device. With the plunger open, the radon gas enters the main chamber through a filter, which prevents the entry of radon decay products (solids).
- The radon gas inside the chamber decays and creates electrostatic charged particles that are attracted to the charged Teflon disc. The charged particles (radon decay products) reduce the voltage on the disc by small amounts.
- The electret is removed from the chamber and its voltage is measured with a specialized reader both before and after the measurement period.
- The difference between the two voltage readings is used to calculate the average radon concentration.

There can be both long short term and long term electrets. These are commonly called ES (short-term) & EL (long-term). EL may be deployed from 1-12 months and ES may be deployed for 2-7 days.

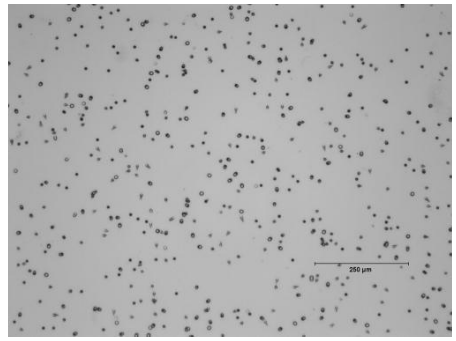
Advantages:

- Results can be given immediately
- Does not require power
- Can be reused after reading the voltages

Disadvantages:

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

A. **Alpha Track Detectors** Alpha track detectors consist of a small piece of plastic or film encased in a container with a filter covered opening. Radon diffuses into the container and alpha particles emitted by radon and its decay products strike the detector and produce submicroscopic damage to the plastic. At the end of the measurement period, the detectors are returned to a laboratory. The damaged tracks are counted using a microscope or counting mechanism. The counted numbers of tracks are mathematically correlated to the radon concentration in air. These are most commonly used for Long-Term radon measurements: 3 to 12 months in duration.



Microscopic "Scratches" caused by radon decay products

Active Devices

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

An advantages of CRMs is that they record radon levels (often in one hour increments). These levels usually vary over time – sometimes greatly. Users can then review that recording to pin-point the times of day when radon is higher in a building. HVAC systems can then be adjusted to lower those levels when a building is usually occupied, as appropriate.

These devices are expensive to buy, require ongoing calibration an annual basis, and many require specialized training to use correctly. CRMs can costly to use in a school, particularly for initial testing, when multiples devices are necessary to test many rooms simultaneously. [But CRMs can also be rented so the renter doesn't directly incur calibration costs.]

SHORT AND LONG TERM TESTS

There are two ways to use radon test kits (passive and 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 in an area (e.g., schoolroom) for a period of 2 to 90 days depending on the device.

  a) Activated Charcoal (AC) devices, which are simple to operate and place without any assistance, may be used to conduct school screening measurements. Test kits may be purchased in a hardware store, department store or home improvement store, or ordered through the mail or Internet. They can be purchased in bulk at a discounted rate. Please note: AC kits require "closed-building conditions" before/during the test, per kit instructions.

  b) Electret Ion Chamber devices are also simple to operate and place, but may be more costly to purchase and operate.

- **Long Term** - A long-term test remains in place for more than 90 days. A long-term test (e.g., a test conducted over the school year) will give a result that is more likely to represent the school year average radon level in a schoolroom. Long-term tests do not require closed building condition.

  a) Alpha track detectors are also simple to operate and place, but are slightly more expensive and measurement results take longer time to obtain.

For initial measurements of schools, short-term passive testing devices are recommended.

MEASUREMENT PROTOCOL/STRATEGY

The short-term test is the suggested method of measuring radon levels. In order to assure adequate test results, only devices that are used for a measurement period of at least 48 continuous hours should be used when testing for radon in school buildings. The following steps should be taken:

Step 1: Initial Measurements

Initial measurements should be short-term measurements of 2-7 days, and should be made in all frequently occupied rooms in contact with the soil, whether the contact is slab-on-grade, a basement, a room above a crawlspace or any combination to provide a quick test of whether or not high radon concentrations are present. Short-term test kits should be placed during colder months (October through March, depending on geographical location).

1. An assessment of the building should be done to determine the number of measurement devices needed. See the Quality Assurance Measurements section for information on the total number of devices, including those needed for quality assurance purposes.

2. Frequently occupied rooms include classrooms, offices, conference rooms, computer rooms, gymnasiums, auditoriums, cafeterias and break rooms. All rooms should be tested simultaneously.

3. Do not test storage rooms, kitchens, bathrooms, stairways, hallways, or elevator shafts.

4. A minimum of one detector test kit must be placed for up to every 2000 square feet of open floor area. For example a 3500 square foot gymnasium would require two test kits.

5. All teachers or frequent adult users should be aware that the room is being tested.

6. Schools shall only be tested for radon during periods when the HVAC system is operating as it does normally.

7. **"Closed-building conditions," as discussed in *Radon Testing Process Guide* (below), must be observed for short-term testing**.

8. In order to get the most accurate long-term test result in a timely manner, we recommend beginning short-term testing in early October such that long-term testing, if needed, can be installed by early November and picked up at the end of the school year.

Perform a follow-up measurement in every room where the initial test result is 4 pCi/L or greater.

Step 2: Follow-up Measurements

If the results of a radon screening test in any frequently occupied room are found to be 4.0 pCi/L or greater, follow-up measurements should be conducted. EPA and OHA recommend that follow-up testing of rooms 4.0 pCi/L or greater be conducted before any mitigation decisions are made. Follow-up testing should start quickly, ideally within one month of receiving initial test results.

Based on the results of the initial Short-Term test for a room, the following steps should be conducted:

- If the result is less than 2.0 pCi/L, Oregon Revised Statute 332.166-167 requires school districts to test again every ten years.
- If the result is between 2.0 pCi/L and 4.0 pCi/L, consider fixing (lowering) the radon in that room.
- If the result is from 4.0 pCi/L to 8.0 pCi/L, perform a follow-up measurement of that room using a Long-Term test. This should be conducted over as much of a nine-month school year as possible, when the room's likely to be occupied. If that result is equal to or greater than 4.0 pCi/L, the radon in the room should be fixed (lowered).
- If the initial test result is equal to or greater than 8.0 pCi/L, conduct a second Short-Term test and average its result with the result of the initial Short-Term test. If the average result of the two Short-Term tests is equal to or greater than 4.0 pCi/L, then radon in the room should be fixed (lowered).

  [A great difference in the results of the short-term tests may indicate a flaw in the testing process, and should be investigated (and retesting considered). There is specific guidance for situations where one of the test results is equal to or greater than 4.0 pCi/L: If the higher result is two or more times the lower result, a repeat test should be done.]

All follow-up measurements in a school building should be conducted simultaneously. Follow-up measurements should be made in the same locations and under the same conditions as the initial measurements (to the extent possible, including similar seasonal conditions and especially HVAC system operation). If follow-up measurements using short-term tests are done, be sure to maintain closed-building conditions. This will ensure that the two results are as comparable as possible.

The higher the initial short-term test result, the more certain you can be that a short-term test should be used rather than a long-term follow-up test. In general, the higher the initial measurement, the greater the urgency to do a follow-up test as soon as possible. For example, if the initial short-term measurement for a room is several times the radon action level (e.g., at or above 8.0 pCi/L or higher), a short-term follow-up measurement should be taken immediately.

Use of Continuous Radon Monitors for Rooms ≥ 4.0 pCi/L after Follow-Up Testing

For these rooms, CRM's may be used to determine radon levels when the room is actually occupied. [See CRM discussion in "Types of Radon Measurement Devices" above.] That may allow, to an extent, for the "fine-tuning" of the room's HVAC system to reduce those levels. Schools might consider collaborating to buy/rent a CRM(s), which could then be used by members of the group for this purpose.

How are Results Interpreted?

Procedures for analyzing test results from detectors, duplicates, blanks and spikes are detailed in the "Interpretation of Initial Results" section.

- **If the follow-up test is short-term, average the results of the initial test & the follow-up. If result is 4.0 pCi/L or above, USEPA recommends that the radon concentration in that room be reduced to below 4.0 pCi/L**

- **If the follow-up test is long-term, and the result is 4.0 pCi/L or above, USEPA recommends that the radon concentration in that room be reduced to below 4.0 pCi/L.**

It is not recommended that schools use a single short-term test as the basis for determining whether or not action needs to be taken to reduce radon levels, before consulting with a certified radon professional. A follow-up measurement to confirm an initial short-term measurement of 4 pCi/L or higher should be conducted before making such a decision. In addition, USEPA studies have shown that the average of two such short-term measurements reduces the possibility of misrepresenting the average radon concentration.

Is Mitigation Needed?

The need to mitigate will depend on radon levels found by follow-up measurements, if needed.

The State of 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 has been certified by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). That list is located at: http://1.usa.gov/1nSvisi

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

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

The professional may perform additional diagnostic testing and ultimately may make recommendations for mitigation. Diagnostics involve the evaluation of radon entry points and the identification of the appropriate radon reduction technique. Mitigation is the design and implementation of a radon reduction strategy.

While ORS 332.166-167 does not specifically require mitigation of elevated radon, both US EPA and OHA strongly suggest that rooms with follow-up measurements above 4.0 pCi/L be mitigated. Very elevated radon concentrations and site-specific considerations may suggest a quicker response rate.

What are the Types of Mitigation Systems?

Schools and large commercial buildings are more complex than residential homes. Yet such intricacy may offer more options for reducing elevated radon. Like most other indoor air contaminants, radon can best be controlled by keeping it out of the building in the first place, rather than removing it once it has entered.

It is likely impossible to reduce a school's radon down to zero. Again, the goal of radon reduction is harm reduction.

Radon can be controlled through:

- HVAC systems. Adjustment to the Heating, Ventilation, and Air-Condition systems serving a room may reduce radon levels to below EPA's action level guideline of 4 pCi/L.
- Soil Depressurization. A suction fan is used to produce a low-pressure field in soil under the building slab. This low-pressure field prevents radon entry by ventilating the gas outside before it has a chance to get drawn into the building.
- Building Pressurization. Indoor/soil pressure relationships are controlled to prevent radon entry. More outdoor air is supplied than exhausted so the building is slightly pressurized compared to both the exterior of the building and the sub-soil area.
- Sealing Entry Routes. Seals are installed at major entry routes to minimize radon entry.
- Zone-specific ventilation. A building's crawlspaces, tunnels, conduits, vaults, etc. may be utilized to design a system that reduces its elevated radon.

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

If, after testing, elevated radon is found in the finished building, a radon fan can easily be added and the system "activated." Under current statute, RRNC is required in all public buildings (including schools) 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 frequently used radon reduction technique is adjustment of a building's HVAC system. This method directly influences radon entry by altering air pressure and dilutions differences between the radon in the soil and building interior. Depending upon the type and operation, an HVAC system can create positive or negative air pressure. Positive pressure can prevent radon entry, while negative pressure enhances radon entry. The positive pressure can be achieved through additional heating, cooling and/or dehumidification, along with enhanced routine operation and maintenance. A number of school districts across the country, upon finding elevated radon in a just a few rooms in a school building, have lowered the radon levels in those rooms by altering the building's HVAC system.

At a certain point, however, such adjustments can reduce the effectiveness (and increase operational costs) of components in this system. Such ongoing operational costs may be greater than the upfront costs of ASD.

If adjustment of a building's HVAC system does not lower a room(s) elevated radon, a common radon reduction method is active soil depressurization (ASD). ASD is especially effective with higher levels of radon. ASD creates a lower pressure in the underlying soil to reverse the flow of air through a building foundation, thereby reducing radon entry. A series of pipes draw radon gas from underlying soil while an inline high suction fan is attached to these pipes to vent the soil gas from beneath the building foundation. ASD is accompanied by sealing radon entry routes, which improves radon removal efficiency and reduces energy costs. ASD, however, 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 difficult, if not impossible, to seal every crack and penetration. Therefore, sealing radon entry routes is often used in conjunction with other mitigation techniques, and not considered a long-term solution by itself.

Planning, Costs and "Economies of Scale" in School Radon Measurement

Given the costs associated with radon testing (labor, test kit costs, shipping, etc.), not to mention what is at stake in terms of human health, school districts should consider two important points:

- **Planning is Critical** – The testing of schools for elevated radon is not difficult, but it does require coordination and planning. With so many "moving parts," particularly around Quality Assurance measures, School Radon Measurement Teams should have a well-thought out testing plan that accounts for shipping times, school calendars, lab schedules, etc. Poorly thought-out testing efforts can lead to inaccurate results and can be costly. For example, testing efforts in school districts in other states have led to invalid results (and thousands of dollars lost) because exposed test kits didn't get to Testing Laboratories in time due to poor planning.

  By going through a well-thought out "dry-run" on paper, staff will likely be able to identify timelines, costs (staff time & test kit costs) and unforeseen barriers. Knowing these, before testing begins, may result in more accurate test results and decreased costs.

  OHA recommends (but does not require) that School Radon Measurement Teams utilize the tools (*Test Kit Location Floor Plan* and *Test Kit Placement Log)* found in the *Step-by-Step Guide for Planning Radon Testing in Oregon Schools*. [See Appendices.]

- **Roving School Radon Measurement Team** - School districts, particularly smaller ones, should consider having a roving School Radon Measurement Team that goes from school to school in the district. Neighboring districts might consider jointly funding such a team to cover all schools in the group. As discussed, groups of schools may want to jointly buy/rent a CRM. These are particularly useful in understanding when radon levels are at their highest (so that HVAC systems can be adjusted to lower those levels when the buildings occupied, as appropriate).

  While every school is a little bit different, the procedures for testing in schools are essentially the same. A team that tests many schools will likely accumulate experience and become more efficient in measuring each school. This decreases the staff time needed to coordinate timelines, place test kits, and analyze results. By joining forces, districts may also be able to buy test kit (and spiking services) in bulk.

QUALITY ASSURANCE

Having radon test results that are accurate is important since mitigation can be expensive. For that reason, OHA strongly recommends that Quality Assurance (QA) measurements should be taken to make sure that testing results are reliable. This requires the use of additional test kits.

For radon testing projects, "quality assurance" refers to maintaining the minimum acceptable standards of three concepts during the entire data collection process: *precision*, *accuracy*, and *bias*. These are all defined below:

"**Precision**" refers to the closeness of two or more measurements to each other. In radon testing, the objective of precision is to see how close are the results of two radon test kits that have been placed side-by-side for the same measurement period. Test kits called "duplicates" are used for his purpose.

While some variation between the "detector" device and the duplicate kit paired with it is expected, an unusually large variation in the results of the two tests may indicate a systematic problem in the measurement process for a building. Using duplicates to determine precision is discussed in the *Quality Assurance Procedures for a School Radon Measurement Program* section below.

"**Accuracy**" is defined as how close the measured value is to the actual value. In other words, were test kits on the site measuring anything *other* than the radon at the school site? In radon testing, test kits called "blanks" are used to determine whether the manufacturing, shipping, storage or processing has affected the accuracy of the testing process for a site. Using blanks to determine accuracy is discussed in the *Quality Assurance Procedures for a School Radon Measurement Program* section below.

"**Bias**" is defined as amount of systematic error inherent to the testing process, including potential defects in the test kits and quality defects of the Testing Laboratory (i.e. the kit manufacturer to which the kit is returned after use for processing). Test kits called "spikes" are used to determine measurement laboratory and test kit accuracy. Using spikes to determine bias is discussed in the *Quality Assurance Procedures for a School Radon Measurement Program* section below.

Types of Test Kits Used in Quality Assurance for Radon Testing

1. **Duplicates:** Duplicates provide an indication of the precision of the measurement. Duplicates are test kits that are placed in the same location alongside the kits used as detectors for the same measurement period.

   The number of duplicates should be 10 percent of the rooms to be tested at a school site.

   A minimum of one duplicate per building is needed. [Round up if a fraction. For example, a school has 55 rooms to be tested, and 10% of those is 5.5 test kits. But the Team should request six kits for spiking.]

2. **Blanks:** Blanks can be used to determine whether the manufacturing, shipping, storage, or processing of the test kit has affected the accuracy of the measurements. They are called blanks because when placed alongside detectors, that are opened, but then immediately resealed. As a result, blanks should have results at or close to 0.0 pCi/L.

   The number of blanks should be 5 percent of the rooms to be tested at a school site [Round up if a fraction.] A minimum of one blank per building is needed.

3. **Spikes**: Spikes evaluate how accurately the detectors supplied by a Radon Testing Laboratory measure radon and how accurate that lab's kit processing is. Spike testing involves exposing kits to known levels of radon in a Certified Performance Test Chamber. Currently, there are two chambers (Bowser-Morner Inc. and Radon Measurement Lab) certified by AARST-NRPP (http://aarst-nrpp.com/wp/test-chambers/) to provide spiking services. Those spikes are returned to the School Radon Measurement Team which sends them (unidentified) to the Testing Laboratory.

   The number of spikes should be 3 percent of the rooms to be tested at a school site. [Round up if a fraction.]

   It's recommended that a device placement and floor plan be developed for each school building to be tested. The serial numbers and locations for devices placed on the site (detector, duplicate & blanks) should be included in the device log. The logs should be retained by the School Radon Measurement Team, but time & date data is copied to/sent along with the kits themselves to the Radon Measurement Laboratory.

Quality Assurance Procedures for a School Radon Measurement Program

Please read this entire section before starting testing. Some steps are time-dependent. All should be done as part of well-planned testing effort. [Adapted from Ohio Dept. of Health, 2015]

1. As discussed above, a School Radon Measurement Team should calculate how many detector kits are needed. This number equals the number of "regular" rooms that are to be measured plus those kits required for "larger" rooms (2000 sq. ft. or larger). [Larger rooms need one test kit per 2000 sq. ft. or portion thereof, so a 3500 sq. ft. gymnasium needs two detector kits.]

2. In addition to those detectors, kits for Quality Assurance (QA) purposes should be purchased in the following proportions: duplicate kits (a number equal to 10% of the rooms to be tested at a school site); blank kits (5% of the rooms to be tested at a school site); and spike kits (3% of the rooms to be tested at a school site). Note: each building to be tested should have, in place, a minimum of one duplicate and one blank.

   IMPORTANT: Test kit percentages for QA are based on the number of rooms to be tested, NOT the number of detector kits to be used.

3. After determining the number of test kits (detectors, blanks, duplicates & spikes) needed for initial measurement of school site(s), kits shouldbe purchased from one manufacturer (and be from one lot). It is most cost effective to purchase in bulk.

4. Once the kits are received, Team staff should randomly draw the kits needed for spiking (the 3%) from the boxes. The serial numbers of the kits should be recorded, noted as the kits being reserved for spike testing, and set aside.

5. For radon measurements of a single school site:

   a. About two weeks before testing is to start, the Team should contact a Certified Performance Test Chamber to discuss spiking services (http://aarst-nrpp.com/wp/test-chambers/). Team should inquire about and understand the chamber's schedule for spiking the kits, and express mailing them back to the sender. A school's testing timeline may be depend on that schedule.

   b. Send kits to the Certified Performance Test Chamber for spiking. The chamber should ship those spiked kits via overnight delivery back to the Team so that their arrival coincides with the end of the measurement period of the school. Spikes can then be included in the same container as the detectors, blanks, and duplicate kits (but not identified as spikes) and shipped overnight) back to Radon Measurement Laboratory.

6. For radon measurements of multiple school sites:

   a. About a month before testing is to begin, the Team should contact a Certified Performance Test Chamber (http://aarst-nrpp.com/wp/test-chambers/) to discuss the chamber's spiking schedule and arrange ongoing spiking services for the duration of the testing project.

   b. With spiking service arrangements in place, the Team should mail the kits designated for spiking (the 3%) to the chamber. Now the Team has a "bank" of kits at the chamber waiting to be spiked. At the Team's request (see below), the chamber will spike the requested number of banked kits with a known amount of radon (spiked), and express mail them to the Team along with documentation on that known level.

   c. The Team will know - in advance – the date that the devices (detectors, blanks, and duplicates) deployed at a particular school site are to be picked up. The Team should contact the chamber with which it has "banked" test kits for spiking and request that a specific number of spiked test kits be sent to a particular school site, again, so their arrival coincides with the end of the measurement period of that school. Spikes can then be included in the same container as the detectors, blanks, and duplicate kits (but not identified as spikes) and shipped overnight back to Radon Measurement Laboratory.

7. In 2-4 weeks, the Team will receive results for all the test kits analyzed. Please see *Interpreting Initial Results* below for procedures on analyzing and applying the test results.

INTERPRETATION OF RESULTS

Interpretation of Initial Results

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

2. For the detector kits that had duplicate kits paired with them, compare the results of the two kits by calculating the Relative Percent Difference (RPD).

$$\text{Relative Percent Difference } (RPD) = \frac{\left| \textit{Initial Result} - \textit{Duplicate Result} \right|}{\textit{Average of Both Results}} \times 100\%$$

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% or more, the data quality should be questioned.

In this case, you should call the Radon Measurement Lab to investigate the situation further. It is possible that the room associated with the questionable duplicate may need to be retested. If the lab doesn't provide a satisfactory answer, a team representative should contact a Radon Measurement Professional to discuss [See below.].

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 Measurement Lab to investigate further. If unresolved, a team representative should contact a Radon Measurement Professional to discuss [See below].

4. Check to be sure that the spike results are accurate by calculating how close the Measured Value (i.e., detector kit result) is to the Reference value (i.e., Spike value reported back by Certified Performance Test Chamber). Calculate the Relative Percentage Error (RPE) for each spike.

$$\text{Relative Percentage Error (RPE)} = \frac{(\text{Measured Value} - \text{Reference Value})}{\text{Reference Value}} \times 100\%$$

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 ensure that bias is not influencing a site's test results. Yet one spike result that's outside the "Control Limit" does not mean that the school site's test results are completely off. In general, one should look for a trend in the values in the "Percent Difference" column/table.

	Expected Range of Variability	In Control	Warning	Out of Control
Relative Percent Error (RPE)	Between +10% and -10%	Between +20% and -20%	Between +30% and -30%	Outside of +30% and -30%

A trend in RPE values that are more than ±30% should be investigated.

In that case, the Team's storage, handling, and kit placement should be reviewed. At the same time, the Radon Measurement Lab should be contacted and the RPE result(s) discussed so that the Lab can review its own procedures. A Team representative should contact a Radon Measurement Professional to discuss. [See below.]

RADON TESTING PROCESS GUIDE

The first step of conducting initial screening measurements is to identify rooms that have a potential for elevated radon levels (e.g., levels of 4.0 pCi/L or greater) during the occupied school year.

1. As suggested, a **Test Kit Placement Log** and a **Test Kit Location Floor Plan** should be prepared for each school in which radon measurements are made. The school's emergency escape map can be used as the floor plan, since it usually provides the most accurate and up-to-date information.

   Test kit location should be accurately recorded on both a Log and Floor Plan. See the *Radon Test Kit Placement Strategy* and *Protocol Checklist, Sample Test Kit Placement Log*, and *Floor Plan* included in Appendix A for additional assistance.

2. Test kits or testing services must meet the current requirements of the national certifying organizations, National Radon Proficiency Program (NRPP, www.nrpp.info) or the National Radon Safety Board (NRSB, www.nrsb.org). Testing must be done following the directions on the test kit.

3. The number of test kits used to measure radon (detectors) must be determined by counting the number of appropriate rooms. One detector kit is used for each room that is 2000 square feet or less. Additional test kits are needed for larger rooms. [See "What Rooms Should Be Tested?" section.].

4. Added to this number should be the test kits needed for Quality Assurance purposes. [See Quality Assurance Measurements" section.]

5. Test kits should be placed in all rooms in contact with the soil or located above a basement or a crawlspace that are frequently occupied by students and school staff. [See "Test Kit Placement Guide" in Appendix A.]

6. Testing should occur during the time that students and teachers are normally present (during weekdays).

7. In addition to placing detectors, additional test kits should be provided to serve as quality control measures (duplicate, blank, and spike measurements). [See "Quality Assurance Measurements" section.]

   Kits designated as blanks and duplicate are placed per "Test Kit Placement Guide" in Appendix A.

   Spike test kits are not physically placed on site, but are used for Quality Assurance purposes. The ordering of spikes from a Certified Performance Test Chamber (and their delivery) should coincide as closely as possible with the date that testing stops and detectors, duplicates, and blanks picked up, so that ALL kits can be mailed to the Radon Measurement Laboratory. [See "Quality Assurance Measurements" section.]

8. All test kits placed in the school site (detectors, duplicates, and blanks) must be noted on the Device Placement Log and Floor Plan by their serial number.

9. Test kits should be placed:

   a. Where they are least likely to be disturbed or covered up.
   b. At least three feet from doors, windows to outside or ventilation ducts
   c. At least one foot from exterior walls
   d. At least 20 inches to six feet from floor
   e. About every 2,000 square feet for large spaces (e.g., a 3500 square foot gymnasium would require two test kits)

   Along with the five-item placement protocol above, School Radon Measurement Teams can simply place the test kit on the teacher's desk or up on a bookshelf, out of the way of students.

   To prevent tampering (like at elementary schools), kits may be suspended from a wall or ceiling (using string and thumb-tack/tape). If they are suspended, they should be 20 inches to 6 feet above the floor, at least 1 foot below the ceiling.

10. Test kits must **NOT** be placed:

    a. Near drafts resulting from heating, ventilating vents, air conditioning vents, fans, doors, and windows.
    b. In direct sunlight
    c. In areas of high humidity such as bathrooms, kitchens, laundry rooms, etc.
    d. Where they may be disturbed at any time during the test.

11. Testing with short-term test kits must be used under closed conditions (closed windows/doors except for normal exit/entry)

    a. *Closed conditions:* Short-term tests should be made under closed conditions in order to obtain more representative and reproducible results. Open windows and doors permit the movement of outdoor air into a room. When closed conditions in a room are not maintained during testing, the subsequent dilution of radon gas by outdoor air may produce a measurement result that falls below the action level in a room that actually has a potential for an elevated radon level. Schools shall only be tested for radon during periods when the HVAC system is operating as it does normally.

    b. All external doors should be closed except for normal use – structural and weatherization defects need to be repaired prior to testing.

    c. Closed conditions must be verified when placing and retrieving test kits.

12. Short-term test kits should be placed during colder months (October through March) depending on geographical location.

    a. *Colder months:* Because testing under closed conditions is important to obtain meaningful results from short-term tests, schools should schedule their testing during the coldest months of the year. During these months, windows and exterior doors are more likely to be closed. In addition, the heating system is more likely to be operating. This usually results in the reduced intake of outside air. Moreover, studies of seasonal variations of radon measurements in schools found that short-term measurements may more likely reflect the average radon level in a room for the school year when taken during the winter heating season. Fortunately, this happens to be when most schools are in session!

    b. *Check and document local weather forecasts prior to placing test kits.* Do not conduct short-term measurements (2-5 days) during severe storms or period of high winds. The definition of severe storm by the National Weather Service is one that generates winds of 58 mph and/or ¾ inch diameter hail and may produce tornadoes.

13. Test Kits should be placed during weekdays with HVAC (heating, ventilation, air conditioning) systems operating as they do normally.

    a. *Weekday testing:* When using (2-5 day) short-term tests, it is recommended that testing be conducted on weekdays. The actual length of time a kit is deployed depends on the manufacturer's instructions.

Suggested timeline:

Monday morning – Place kits (detectors/duplicates/blanks) per *Test Kit Placement Log* created for school. Record data, as needed, on *Log*.

Thursday morning – Pick up kits, record as needed, ship with (previously requested & received) spiked test kits to Radon Measurement Laboratory.

    b. Air conditioning systems that recycle interior air may be operated.

14. Window air conditioning units may be operated in a re-circulating mode, but must be greater than 20 feet from the test kit.

15. Ceiling fans, portable humidifiers, dehumidifiers and air filters must be more than 20 feet from the test kit.

16. Portable window fans should be removed or sealed in place.

17. Fireplaces or combustion appliances (except for water heaters/cooking appliances) may not be used unless they are the primary source of heat for the building.

18. If radon mitigation systems are in place in the school, they should be functioning.

19. Schools should *avoid* conducting initial measurements under the following conditions:

    a. During abnormal weather or barometric conditions (e.g., storms and high winds). If major weather or barometric changes are expected, it is recommended that the 2 to 5-day testing be postponed. USEPA studies show that barometric changes affect indoor radon concentrations. For example, radon concentrations can increase with a sudden drop in barometric pressure associated with storms.

    b. During structural changes to a school building and/or the renovation of the building's envelope or replacement of the HVAC system

Follow-up Measurements

Follow-up testing (in rooms with initial short-term measurement of 4.0 pCi/L or higher) should start within one month after receiving the initial test results. Follow-up testing must be made in the same location in a room. When conducting follow-up testing using short-term methods should be done in the same conditions as the initial measurement. Follow-up testing using passive short-term test kits should follow the same Quality Assurance procedures and requirements (i.e. percentages of duplicates/blanks/spikes). Follow directions under *Radon Test Placement Strategy and Protocol Checklist* and *Test Kit Placement* again.

Interpretation of Follow-Up Test Results

Perform the same Quality Assurance calculations as were done for initial testing. Questions about discrepancies in Quality Assurance results should be directed to a Radon Measurement Professional.

Report of Results & Distribution

ORS 332.166-167 requires that school districts make all test results available: to the district's school board; the Oregon Health Authority (to post on its website), and readily available to parents, guardians, students, school employees, school volunteers, administrators and community representatives at the school office, district office or on a website for the school or school district.

Radon Measurement Professionals

Questions about the Quality Assurance discrepancies listed above should be directed to a Radon Measurement Professional.

The State of Oregon does not regulate or license radon measurement professionals. The Oregon Radon Awareness Program does have a list of companies with at least one radon measurement technician on staff who has been certified by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). That list is located at: http://1.usa.gov/1Vhijhx

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

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

AFTER RECEIVING RESULTS OF FOLLOW-UP TESTING

US EPA, OHA Oregon Radon Awareness Program, and numerous non-governmental groups recommend that the school district take action to reduce the radon level in those rooms where the average of the initial and follow-up short-term kit results OR the result of the long-term kit used in follow-up is 4.0 pCi/L or more.

Although not required of school districts under ORS 332.166-167, it is recommend that school administration direct appropriate staff to adjust the building's HVAC system and then retest. If this doesn't reduce the radon below 4.0 pCi/L, school districts have the option of hiring a radon mitigation professional to reduce elevated radon levels identified through testing.

The State of 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 mitigation technician on staff who has been certified by the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB). That list is located at: http://1.usa.gov/1nSvisi

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

This list should be used for informational purposes only and is not intended to be an endorsement by the Oregon Health Authority of any mitigation company. These organizations are not the only sources of radon services.

When Should Periodic Retesting be Done?

Initial testing should be conducted in accordance with ORS 332.166-167 before January 1, 2021. Because buildings age and ground beneath them settles, radon entry may increase due to cracks in the foundation. For that reason, ORS 332.166-167 requires that schools be tested once every 10 years regardless of initial testing results or whether mitigation was done.

Suggested times, for retesting, in addition to that required under ORS 332.166-167, are as follows:

1. Current national guidelines (ANSI/AARST, 2014) recommend that school buildings be re-tested every five years.

2. If radon mitigation measures have been implemented in a school, retest these systems as a periodic check to ensure that the radon mitigation measures are working. EPA does not provide a specific interval, but OHA recommends that schools with radon mitigation measures retest every 5 years.

3. Retest after major renovations to the structure of a school building or after major alterations to a school's HVAC system. These renovations and alterations may increase radon levels within a school building.

4. If major renovations to the structure of a school building or major alterations to a school's HVAC system are planned, retest the school before initiating the renovation. If elevated radon is present, radon-resistant techniques can be included as part of the renovation.

Please direct questions to:

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

FREQUENTLY ASKED QUESTIONS ABOUT RADON AND SCHOOLS

1. Does radon cause headaches, eye irritation, or sick-building syndrome? *No.*

2. Do children have a greater risk of cancer from radon exposure?

   Children usually are more sensitive to environmental pollutants; however, there is no conclusive data right now that shows that children are more at risk than adults from radon exposure.

3. Is there a hazard from touching/being near the radon test kit? *No, although kits should be kept away from very young children (toddlers) so they don't eat or chew on them.*

4. Do building materials emit radon?

   The primary source of radon in a building or home is from the soil underneath it. However, there may be a few building materials that will emit small amounts of radon gas, such as granite, concrete, gypsum board (sheet rock), bricks, and field stone. However, this is RARELY the case because most of these materials are very dense. This means that if there is radon-producing radium in these materials, only a small amount of the radon gas near the surface ever makes it out into the environment.

5. Should testing be delayed if the school is planning major renovations to the building or the HVAC system?

   Initial and follow up tests should be conducted prior to major HVAC or building renovations. Testing can show if a radon mitigation system needs to be installed as a part of renovation. Testing must also be done after renovation.

6. Should upper floors of a school or building be tested? Does this mean that upper floors never have elevated levels?

   Upper floors may indeed have elevated levels of radon. However, measurements in ground floor rooms are likely to be a good indicator of radon levels for all floors.

7. In schools with a basement level (below ground level), the first floor is often built at ground level, and therefore is in contact with the soil, only along its outside edge. Should this floor be tested?

   Although this floor appears to have limited contact with the soil, the outside rooms may have openings permitting radon entry and should be tested if they are frequently occupied. ORS 332.166-167 requires that all frequently occupied rooms in contact with the soil or above a basement or crawlspace be tested.

8. Nearby homes and schools have reported no elevated levels of radon. Should we still test?

   Yes, radon levels vary with geology, building structure, HVAC systems, etc. The only way to know if radon is present is to test. ORS 332.166-167 states school buildings shall be tested every 10 years, current national guidelines (ANSI/AARST, 2014) recommend that school buildings be re-tested every five years (or whenever there is significant renovation or change to a building's the HVAC system).

9. What are the costs of testing in schools for radon?

   The cost may be dependent upon the number of rooms to be tested and the type of test kit used, but on average, radon testing of schools in Oregon costs about $10 per tested room. This assumes short-term test kits are purchased in bulk and that school staff perform the testing.

10. If a room's short term initial test result is very high (for example above 100 pCi/L) should a follow-up measurement be taken?

    Yes, follow up measurements, even if the initial ones are high, are recommended before making any further decisions.

11. Should a room be retested if there evidence of tampering? *Yes.*
12. How do you place radon test kits in large, open spaces such as cafeterias, gymnasiums, or auditoriums?

    Test kits may be hung from the ceiling and or wall using string and masking/duct tape. Be sure to hang them per the "Test Kit Placement Guide."
13. How do we test partitioned classrooms?

    Classrooms with movable partitions should be individually tested.
14. Can you test during unusual weather conditions (heavy rain, snow or wind)?

    Avoid testing during these conditions.
15. Should we take quality assurance duplicates and blanks during the follow up tests?

    Yes, per the "Interpretation of Results" section above. However, there are generally fewer samples taken for follow-up testing
16. When two devices (duplicates) are placed in a room during initial testing, which measurement result is taken as the test result?

    Both tests are recorded, but the average is taken as the test result.
17. What should be done if a device is picked up late or handled incorrectly?

    All test kits should be handled in accordance with manufacturer's instructions. If there is any discrepancy or problem, the serial number of the device should be recorded and noted to the laboratory doing the analysis. The actual time device was picked up and a brief description of how the device was mishandled should be included in log.

REFERENCES

American Cancer Society, 2015. Cancer Facts & Figures 2015. American Cancer Society, Atlanta.

ANSI/AARST *Protocol for Conducting Measurements of Radon & Radon Decay Products in Schools & Large Buildings*, 2014 (national radon standards)

EPA, 1992. "National Residential Radon Survey: Summary Report" USEPA (EPA 402/R- 92/011. October 1992.

EPA, 1993. "Radon Measurement in Schools Revised Edition" USEPA Air and Radiation (EPA 402-R-92-014) July 1993

EPA 1994a. "Reducing Radon in Schools: A Team Approach" USEPA Air and Radiation (EPA 402-R-94-00b) April 1994.

EPA, 1994b. "Radon Prevention in the Design and Construction of Schools and other Large Buildings" USEPA Air and Radiation (EPA 625-R-92-016) June 1994

EPA, 1994c. "Radon Measurement in Schools: Self-Paced Training Workbook" USEPA Air and Radiation (EPA 402- B-94-001) October 1994.

Klepeis NE, Nelson WC, Ott WR, Robinson JP, Tsang AM, Switzer P, Behar JV, Hern SC, Engelmann WH, 2001. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. J Expo Anal Environ Epidemiol. 2001 May-Jun;11(3):231-52.

National Research Council, 1999. "Health Effects of Exposure to Radon". Committee on Health Risks of Exposure to Radon (BEIR VI), Board on Radiation Effects Research, Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C.

Ohio Dept. of Health, Radon Licensing Program, "School Radon Testing Checklist," 2015

Burkhart James F., Radon Measurement Lab (RML), 2015

Siegel RL. Miller KD, Jemal A. CA: A Cancer Journal for Clinicians, 2015 Jan; 65 (1): 5-29

US Surgeon General, 2005. "Surgeon General Releases National Health Advisory On Radon", US Health and Human Services Press Release, January 13, 2005. Accessed at http://www.adph.org/radon/assets/surgeon_general_radon.pdf.

WEBSITES

School staff, parents, and students may be interested in additional information on radon. The Oregon Radon Awareness Program suggests the following radon websites:

1. Environmental Protection Agency (EPA) [www.epa.gov/radon]
   EPA's main page on everything radon.

2. EPA's Radon in Schools page [www.epa.gov/radon/radon-schools]

3. National Radon Program Services [www.sosradon.org]
   This EPA-funded program is nationally-recognized leader in radon education.

4. National Cancer Institute's Radon page [www.1.usa.gov/1qGOOtM]

5. Oregon Field Guide: Radon [http://bit.ly/1SLRgWC]

   This 12-minute episode, from Oregon Public Broadcasting, provides an excellent introduction on why elevated radon is a concern in Oregon.

6. Oregon Health Authority's Frequently Asked Questions on Radon [www.healthoregon.org/radon]
   In addition to FAQ's, OHA's main radon page has information on radon risk in Oregon and how homes can easily be tested.

GLOSSARY

Radon - A gaseous radioactive decay product of radium.

Blanks - Measurements made by analyzing unexposed (closed) detectors that accompanied exposed detectors to the field. The School District use of blanks is to assess any change in analysis result caused by exposure other than in the environment to be measured. Background levels may be due to leakage of radon into the detector, detector response to gamma radiation, or other causes.

Closed-Building Conditions - Means keeping all windows closed, keeping doors closed except for normal entry and exit, and not operating fans or other machines which bring in air from outside. Fans that are part of a radon-reduction system or small exhaust fans operating for only short periods of time may run during the test.

Duplicates - Duplicate measurements provide a check on the precision of the measurement result and allow the user to make an estimate of the relative precision. Large precision errors may be caused by detector manufacture or improper data transcription or handling by suppliers, laboratories, or technicians performing placements. Precision error can be an important component of the overall error. The precision of duplicate measurements are monitored and recorded as quality records.

Spikes – Measurements used to assess the accuracy of a lab analysis and/or how accurately detectors supplied by a laboratory (i.e. test kit manufacturer) 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). The process for completing this aspect of a radon measurement effort's Quality Assurance/Quality Control plan is laid out in the *Radon Test Placement Strategy and Protocol Checklist* below.

APPENDIX A: RADON TEST PLACEMENT PROTOCOL CHECKLIST

NOTE: This document has been prepared to aid schools and school districts in conducting radon measurements in schools. The step-wise approach is aimed to help school districts determine where to test, how many test kits are required, where to place test kits, and proper documentation of the process.

This document is meant to be used as a general guideline, not a mandate, as each school will present different situations. If specific questions or issues arise regarding testing in your school contact the Oregon Radon Awareness Program at 971-673-0440 or email radon.program@state.or.us.

IMPORTANT: Because radon test kits needed for initial measurements of a school site should be from the same manufacturing batch, they need to be ordered at one time.

Test Kit Placement Guide

Once the number of test kits is determined, they need to be placed in the frequently-occupied rooms as identified in the "What Rooms Should Be Tested? "Section above.

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.

☐ HVAC system is operating as it normally would when students and faculty are present.

☐ Testing is being done during a time that students and faculty are present.

2) As detectors are placed in the rooms determined during section 1, thorough and accurate data needs to be recorded on the device log and floor plan (see sample below).

Protocol for all test kits include the following; be sure that each detector placed 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 1 foot from all exterior walls
☐ at least 20 inches to 6 feet from the floor
☐ out of direct air flow from vents
☐ four feet from heat source

To protocol above, School Measurement Teams in other states simply <u>place the test kit on the teacher's desk</u> or up (out of the way of students) on a bookshelf.

3) Specific protocol for duplicate measurements. If the test kit you are placing is duplicate measurement also be sure to:

☐ Placed duplicate (side-by-side) test kit 4-5 inches away from test kit for that room.

4) Specific protocol for blank measurements. If the test kit you are placing is a blank measurement, also be sure to:

- ☐ Unwrap blanks, open, but then immediately close and reseal them.
- ☐ Place the test kit next to the detector kit(s) for the room 4-5 inches away.

5) Specific protocol for spiked test kits.

- ☐ Arrange for the spiked test kits to arrive back from the Certified Performance Test Chamber to the School Measurement Team as close to the day that kits are retrieved from the school as possible. [See *Quality Assurance Procedures for a School Radon Measurement Program*.]

6) Testing Period.

The minimum length of time test kits should be left out is 48 hours, but not exceed seven days. [It's best to follow test kit manufacturer's instructions for more specific recommendations.] It's best if devices should be left in place for four days to ensure optimum results.

Many schools place short-term kits on Monday morning and pick them up on Thursday morning.

Retrieving Kits. Once the testing period has ended, all test kits placed at a school site (detectors, duplicates, & blanks) need to be retrieved. This should be done on the same date. Complete the data sheet when retrieving detectors.

- ☐ Record ending date and time (kits were pick up) information, per the "Test Kit Placement Log" [Appendix D]

- ☐ Record ending information on the test kit package (if required).

7) Prepare and mail all kits.

- ☐ Seal and prepare test kits to be mailed to the lab by the manufacturer's instructions.
- ☐ Include those spiked kits (not identified as such) in the <u>same</u> box(es) as other kit types.
- ☐ Mail all test kits (detectors, duplicates, blanks, spikes) to the Radon Measurement Laboratory using a mail service that guarantees delivery to the laboratory within two days at maximum, but **preferably overnight** shipping.

APPENDIX B: SIGNAGE FOR SCHOOL RADON MEASUREMENT

On the following page is a sign that that School Radon Measurement Teams may use, as needed, to let school staff, parents and students know that measurement for elevated radon in the school is taking place.

DO NOT TOUCH! RADON TEST IN PROGRESS

This is a screening test for the Sample School District #123 and the radon detector should not be disturbed. Windows should remain closed and the radon detector will be picked up on______________________.

Picture of Sample detector is placed here.

The Sample School District #123 is testing for radon because radon is a colorless, odorless, naturally occurring radioactive gas that comes from uranium in the soil and can cause lung cancer. The Surgeon General warned about the health risk from exposure to radon in indoor air. Because radon is the leading cause of lung cancer for non-smokers in the US and breathing it over prolonged periods can present a significant health risk, the Surgeon General urged Americans to test their homes. The United States Environmental Protection Agency (USEPA) estimates that around 21,000 lung cancer related deaths occur annually in the US with about 275 of those in Oregon.

Because of the danger of radon, every occupied school building of a school district shall be tested every 10 years for radon per ORS 332.166-167.

For questions about this test, contact: ____

APPENDIX C: MEMO TO PARENTS & STAFF ABOUT RADON MEASUREMENT

Before radon measurement begins, schools may want to notify parents and school staff of the effort. Below is an example memo which can be customized.

EXAMPLE memo to be sent to school staff and parents before testing begins

To: _____ Date:

From: Principal or Superintendent

Re: Testing for Elevated Radon at [insert name of school]

An important step is being taken to ensure that the buildings of [insert name of school] are healthy and safe.

This is to notify you that initial testing for elevated radon at [insert name of school] will be conducted starting [insert date]. Under a 2015 Oregon law (ORS 332.166-167), Oregon schools must be initially tested for elevated radon on or before January 1, 2021.

The radioactive gas, radon, is the number one cause of lung cancer among non-smokers, according to EPA estimates. Elevated radon is found naturally in soil across the country and under all types of structures (including homes).

To test for elevated radon at [insert name of school], small devices will be placed in each of the occupied rooms that are in contact with the ground, starting [date]. These devices will picked up on [date]. Test results will be available at the district office on or around [approximate dates].

The test devices looks like [describe: 1) for example, alpha track, a small black cylinder about 1 ½ inches across; 2) for charcoal adsorption: cardboard envelope packet; 3) etc. A picture can be inserted here]. Devices may be placed in somewhat hidden locations, where possible. Please do not tamper with or move test kits, and keep exterior windows and doors closed (except for normal entry/exit) during the testing period.

While school occupants may be exposed to elevated levels of radon in schools, current data from the United States Environmental Protection Agency (USEPA) suggests radon exposure at home is the number one source of radon exposure for most people. USEPA and the Oregon Health Authority (OHA) recommend that all homes, regardless of location and type, be tested.

Please see OHA's Frequently Asked Questions about radon, including information on the health effects, at www.healthoregon.org/radon. Information on how homes can be tested easily and inexpensively is also found at this website. You can request printed information on radon by contacting OHA's Radon Awareness Program at: 971-673-0440 or radon.program@state.or.us.

If you have further questions or concerns regarding radon testing at [insert name of school], please feel free to contact [name, such as health and safety coordinator] at [phone or email].

Thank you, in advance, for your cooperation.

APPENDIX D: STEP-BY-STEP GUIDE FOR PLANNING RADON TESTING

Per ORS 332.166-167, Oregon school districts shall develop a plan for testing schools under their jurisdiction for elevated levels of radon and submit it to the Oregon Health Authority on or before **September 1, 2016.**

Below is a recommended step-by-step guide for planning for radon testing at a specific school site. It's intended to be used with the other information in OHA's *Testing for Elevated Radon in Oregon Schools*.

By going through well-thought out "dry-run" on paper, staff (e.g. School Radon Measurement Teams) will likely be able to identify timelines, costs (staff time & test kit costs) and unforeseen barriers. Knowing these, before testing begins, may result in more accurate test results and decreased costs.

1. Identify rooms to be tested

ORS 332.166-167 specifies that "at a minimum, any frequently-occupied room in contact with the ground or located above a basement or a crawlspace" should be tested.

Examples of such rooms include: offices, classrooms, computer rooms, conference rooms, gyms, auditoriums, cafeterias & break rooms. This does not mean storage rooms, bathrooms, stairways, hallways, kitchens or elevator shafts.

Staff should procure a copy of the school's emergency escape map can be used as the floor plan, since it usually provides the most accurate and up-to-date information. The map can be used to identify the "frequently-occupied rooms" at a particular school site. As discussed below, that map can also be used to indicate which test kit types will go in which room.

Make sure all rooms in the building floor plan are individually labeled; if they are not then create labels for them.

2. Determine the number of test kits needed.

a) Count all frequently-occupied rooms, as defined in ORS 332.166-167.

At the end of section 2a) you should have a rough list of rooms that need to be tested.

___________Number of rooms

b) Determine if any of the rooms selected are larger than 2,000 square feet.

If YES, how many?

Determine the number of test (detectors) kits needed to test the entire school site:

__________ (total number of rooms after section 2a).

__________ (number of rooms over 2,000 square feet).

__________ (number of rooms over 4,000 square feet).

__________ (number of rooms over 6,000 square feet).

TOTAL __________ Number of Detector Kits Needed to Test the School Site

3. Determine the Number of Quality Control Measurements Needed

a) Determine the number of duplicate measurements that need to be deployed during measurement. Rooms to be tested x 0.10 (10%) =___________
[NOTE: Round up to the next whole number. Remember, a minimum of one duplicate kit per building.]

b) Determine the number of blank measurements that need to be deployed during measurement. Rooms to be tested x 0.05 (5%) =___________
[NOTE: Round up to the next whole number. Remember, a minimum of one blank kit per building.)

c) Determine the number of spike measurements that need to be deployed during measurement. Rooms to be tested x 0.03 (3%) =___________
[NOTE: Round up to the next whole number.]

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

_______ = Number of detector kits determined in Section 2

_______ = Number of duplicate tests determined in Section 3a.

_______ = Number of blank tests determined in Section 3b.

_______ = Number of spike tests determined in Section 3c.

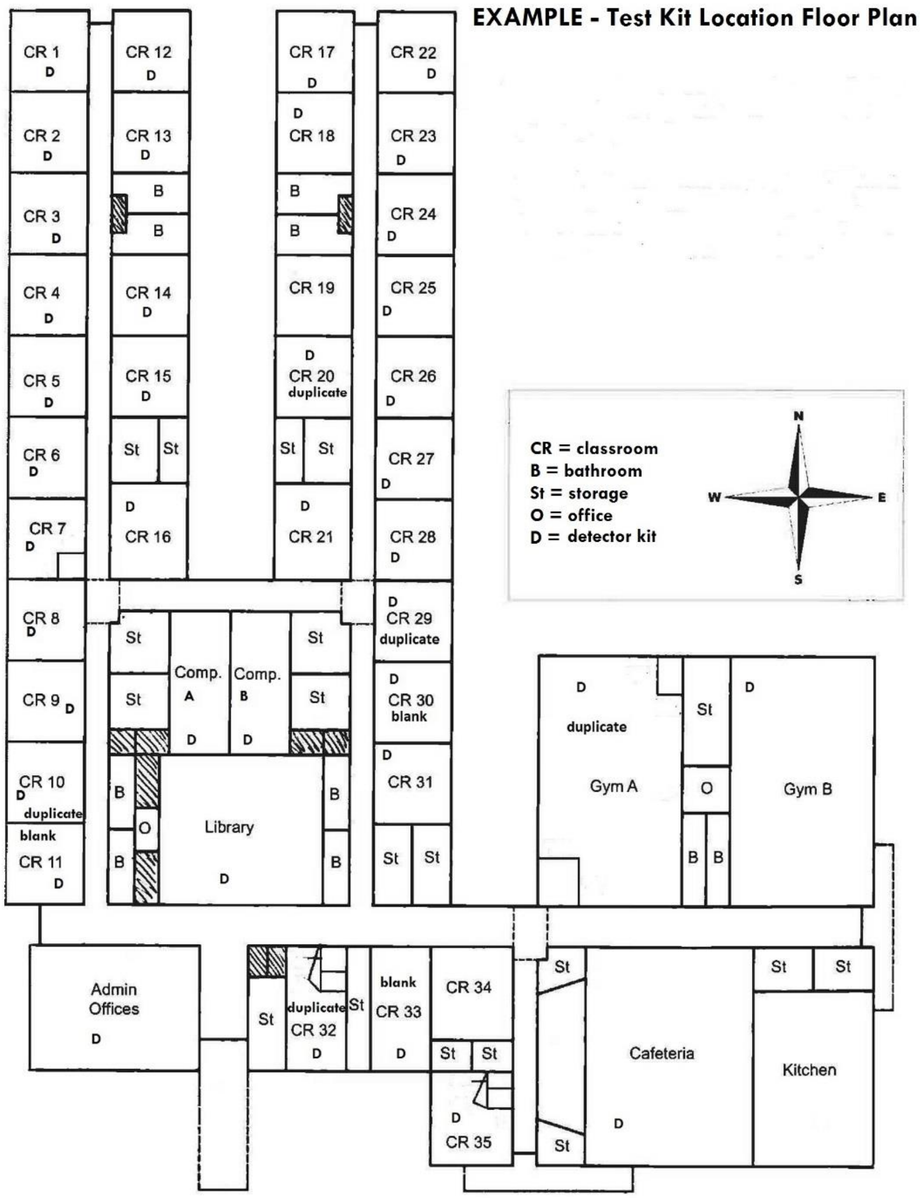
TOTAL _______ = **Number of Test Kits Needed to Test the School Site**

5. Use a Test Kit Location Floor Plan to create Test Kit Placement Log(s)

To determine School Radon Measurement Teams can use a template of the school's emergency escape plan to decide which rooms the different types of test kits (detectors, blanks & duplicates) will be placed. These documents will guide the planning of a radon testing effort as well as the actual testing itself.

The School Floor Plan (see sample below) is used is used to create Test Kit Placement Log(s) for the school (next page) which indicates where the detectors, duplicates, and blanks are to be placed when initial testing of the school for elevated radon begins.

IMPORTANT: Because each building on a school site should have a minimum of one detector, one duplicate and one blank, a separate **Test Kit Placement Log** should be created for each building on the school site.


EXAMPLE - Test Kit Location Floor Plan
CR = classroom
B = bathroom
St = storage
O = office
D = detector kit
N
S
E
W
CR 1
CR 2
CR 3
CR 4
CR 5
CR 6
CR 7
CR 8
CR 9
CR 10
duplicate
blank
CR 11
CR 12
CR 13
CR 14
CR 15
CR 16
CR 17
CR 18
CR 19
CR 20
duplicate
CR 21
CR 22
CR 23
CR 24
CR 25
CR 26
CR 27
CR 28
CR 29
duplicate
CR 30
blank
CR 31
Comp. A
Comp. B
Library
Gym A
duplicate
Gym B
Admin Offices
duplicate
CR 32
blank
CR 33
CR 34
CR 35
Cafeteria
Kitchen

Test Kit Placement Log

Below is an example “Test Kit Placement Log” that is based on the example “Test Kit Location Floor Plan” above. The Log created for a school will be used for both planning the placement of test kits, and recording data when testing of the school actually takes place. A blank “Test Kit Placement Log” that can be used, along with the “Test Kit Location Floor Plan” for that school to plan is found below.

Directions: Using a school’s Test Kit Location Floor Plan, please indicate in the Log’s “Room Description:” column the rooms that will have detectors (D), blanks & duplicate test kits. These should be selected per the guidance of in the “What Rooms Should Be Tested?” and the “Quality Assurance” sections of this Protocol. On the far right of the log, please indicate the “Type of Test” (for that row).

[Although the Test Kit Placement Log has rows reserved for the 10% of rooms at a school site where duplicates should be placed (yellow/lighter shading), and for the 5% of rooms where blanks should be placed (gray/darker shading, these are for the Team’s convenience. The selection of rooms for duplicates and blanks should be at random. Remember, there needs to be a minimum of one duplicate and blank per building.]

STOP. For the purposes of planning radon measurement at a school site, this is all that’s needed. The remaining fields in the Log will be filled out when testing of the school actually begins.

[Regarding the remaining fields: “Canister Serial #” is the unique identification number found on each test kit; “Date & Timed Opened” and “Date & Time Closed” refer to the actual moments when kits are placed and “activated” to begin measuring the radon in the room (and then stopped). This information, when reported to the Radon Measurement Laboratory, helps it adjust its equipment for an accurate analysis of the test kit. Note: staff who will actually conduct testing may be identified when testing actually begins]

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

www.healthoregon.org/radon

EXAMPLE - Test Kit Placement Log

Name & Physical Address of School Being Tested: South Elementary – ## Street, Salem, OR 97304
Building: Main building **Radon Testing Contact at School:** Peter Progeny, 503-724-3135
Name of Individuals Performing Testing:
Sammy Sampleton (Logger); Rosie Radon (Placer)

Room Description (per Floor Plan)	Canister serial #	Date Opened	Time Opened	Date Closed	Time Closed	Type of Test D = detector kit
CR1	100135	11/7/2016	6:00am	11/10/2016	6:30 am	D
CR2	100137	11/7/2016	6:02am	11/10/2016	6:37 am	D
CR 3	100139	11/7/2016	6:04am	11/10/2016	6:40 am	D
CR 4	100140	11/7/2016	6:05am	11/10/2016	6:44am	D
CR 5	100141	11/7/2016	6:06am	11/10/2016	6:47 am	D
CR 6	100142	11/7/2016	6:07am	11/10/2016	6:50 am	D
CR 7	100143	11/7/2016	6:08am	11/10/2016	6:56 am	D
CR 8	100144	11/7/2016	6:9am	11/10/2016	6:59 am	D
CR 9	100145	11/7/2016	6:11am	11/10/2016	7:03 am	D
CR 10	100146	11/7/2016	6:13am	11/10/2016	7:07 am	D
same as above	100147	11/7/2016	6:13am	11/10/2016	7:10 am	Duplicate
CR 11	100148	11/7/2016	6:14am	11/10/2016	7:15 am	D
same as above	100149	11/7/2016	6:14am	11/10/2016	7:23 am	Blank
CR 12	100150	11/7/2016	6:16am	11/10/2016	7:27 am	D
CR 13	100151	11/7/2016	6:17am	11/10/2016	7:30 am	D
CR 14	100153	11/7/2016	6:19am	11/10/2016	7:35 am	D
CR 15	100154	11/7/2016	6:20am	11/10/2016	7:43 am	D
CR 16	100155	11/7/2016	6:22am	11/10/2016	7:47 am	D
CR 17	100156	11/7/2016	6:23am	11/10/2016	7:49 am	D

[Adapted from Burkhart, 2015]

(example log continued)

Room Description (per Floor Plan)	Canister serial #	Date Opened	Time Opened	Date Closed	Time Closed	Type of Test
CR 18	100157	11/7/2016	6:24am	11/10/2016	8:03 am	D
CR 19	100158	11/7/2016	6:25am	11/10/2016	8:07 am	D
CR 20	100159	11/7/2016	6:26am	11/10/2016	8:10 am	D
same as above	100160	11/7/2016	6:27am	11/10/2016	8:15 am	Duplicate
CR 21	100161	11/7/2016	6:28am	11/10/2016	8:23 am	D
CR22	100162	11/7/2016	6:30am	11/10/2016	8:27 am	D
CR 23	100163	11/7/2016	6:31am	11/10/2016	8:27 am	D
CR 24	100164	11/7/2016	6:32am	11/10/2016	8:30am	D
CR 25	100165	11/7/2016	6:37am	11/10/2016	8:37 am	D
CR 26	100166	11/7/2016	6:39am	11/10/2016	8:40 am	D
CR 27	100167	11/7/2016	6:40am	11/10/2016	8:41 am	D
CR 28	100168	11/7/2016	6:41am	11/10/2016	8:43 am	D
CR 29	100169	11/7/2016	6:44am	11/10/2016	8:45 am	D
same as above	100170	11/7/2016	6:46am	11/10/2016	8:46 am	Duplicate
CR 30	100171	11/7/2016	6:48am	11/10/2016	8:47 am	D
same as above	100172	11/7/2016	6:49am	11/10/2016	8:49 am	Blank
CR 31	100173	11/7/2016	6:49am	11/10/2016	8:49 am	D
CR 32	100174	11/7/2016	6:49am	11/10/2016	8:49 am	D
same as above	100175	11/7/2016	6:51am	11/10/2016	8:52 am	Duplicate
CR 33	100176	11/7/2016	6:53am	11/10/2016	8:52 am	D
same as above	100177	11/7/2016	6:54am	11/10/2016	8:55 am	Blank
CR 34	100178	11/7/2016	6:55am	11/10/2016	8:57am	D
CR 35	100179	11/7/2016	6:56am	11/10/2016	8:59 am	D
Computer A	100182	11/7/2016	7:04am	11/10/2016	9:15 am	D
Computer B	100183	11/7/2016	7:05am	11/10/2016	9:18 am	D

(example log continued)

Room Description (per Floor Plan)	Canister serial #	Date Opened	Time Opened	Date Closed	Time Closed	Type of Test
Gym A	100184	11/7/2016	7:06am	11/10/2016	9:20 am	D
Gym A	100185	11/7/2016	7:10am	11/10/2016	9:24 am	D*
same as above	100186	11/7/2016	7:11am	11/10/2016	9:30 am	Duplicate
Gym B	100187	11/7/2016	7:14am	11/10/2016	9:32 am	D
Gym B	100188	11/7/2016	7:15am	11/10/2016	9:35 am	D
Admin. Offices	100189	11/7/2016	7:30am	11/10/2016	9:37 am	D
Cafeteria	100190	11/7/2016	7:38am	11/10/2016	9:42am	D

*

*Gym A is 2800 square foot space, so has two detector kits. But because duplicates, like other QA kits, are determined by the number of rooms in the building, only on the detector kits is paired with a duplicate.

Test Kit Location Floor Plan

Name & Physical Address of School Being Tested:
Radon Testing Contact at School:

School's Floor Plan

Test Kit Placement Log

Name & Physical Address of School Being Tested:
Building: Log Page: of for school.
Radon Testing Contact at School:
Name of Individuals Performing Testing:
(Logger);
(Placer of Test Kits)

Room ID (per Floor Plan)	Test Kit Serial #	Date Opened	Time Opened	Date Closed	Tim
same as above					
same as above					
same as above					

(Use additional copies of this page for each building with frequently-used rooms at school site, as needed.]