

# **Testing for Elevated Radon in Oregon Schools Protocol and Plan**

**For the**

Sweet Home School District  
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Sweet Home, OR 97386



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**TABLE OF CONTENTS**

INTRODUCTION	1
PLAN OBJECTIVES	2
WHAT IS RADON?	3
WHY IS RADON A PROBLEM?	3
HOW IS RADON REPORTED?	4
WHAT IS THE USEPA ACTION LEVEL?	4
WHAT ARE THE ROUTES OF RADON ENTRY?	5
ENVIRONMENTAL FACTORS INFLUENCING RADON CONCENTRATIONS	7
TYPES OF RADON MEASUREMENT DEVICES	8
SHORT AND LONG TERM TESTS	11
MEASUREMENT PROTOCOL/STRATEGY	11
QUALITY ASSURANCE	14
INTERPRETATION OF RESULTS	16
AFTER RECEIVING RESULTS OF FOLLOW-UP TESTING	21
REFERENCES	23
GLOSSARY	24
APPENDIX A: RADON TEST SITE PLAN/PLACEMENT CHECKLIST/SIGNAGE	25
APPENDIX B: LABORATORY RESULTS AND CHAIN OF CUSTODIES	26
APPENDIX C: COMMUNICATIONS/LETTER TO PARENTS AND STAFF	27
APPENDIX D: OREGON RADON RULES ORS 332.166-167	28

## INTRODUCTION

This Testing Protocol and Plan has been developed for Sweet Home School District to comply with regulations passed in Oregon in 2015. It is intended to ensure compliance with the below mentioned rules and will change and require updates as rules and regulations are modified through time.

Radon is the number one cause of lung cancer among non-smokers, according to Environmental Protection Agency (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) 2931 so that elevated radon levels in Oregon schools would be known. HB 2931 later became Oregon Revised Statute (ORS) 332.166-167. As directed by the statute, this plan, developed by Kelsay Environmental, 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 to be completed 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.

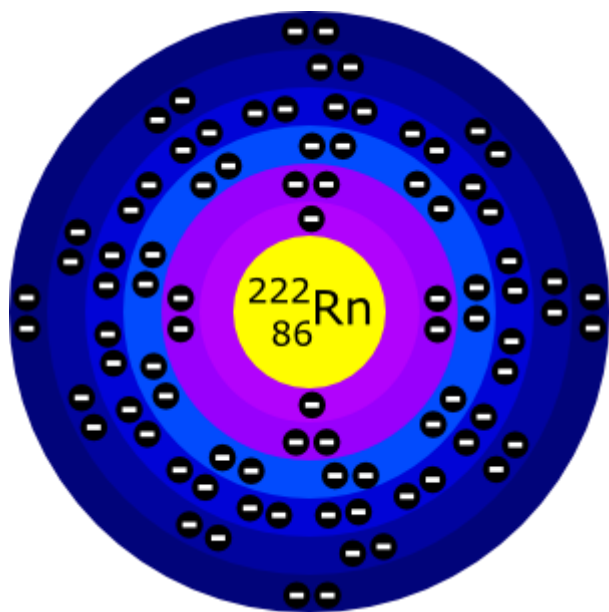
## **RADON PROTOCOL AND PLAN OBJECTIVES**

This Radon Testing and Protocol Plan addresses objectives for radon screening measurements at Sweet Home School District. The objectives are:

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?

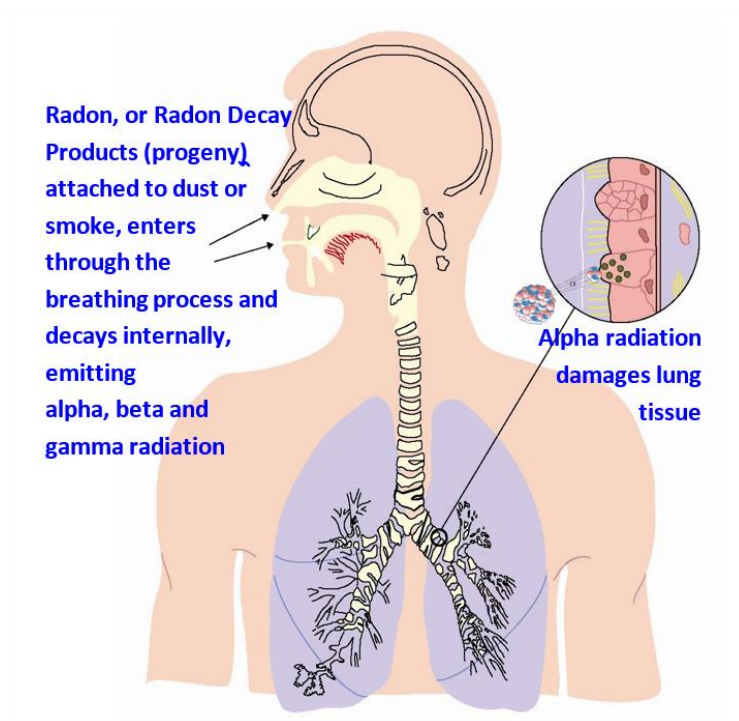
Radon comes from natural deposits of uranium in the soil and is found everywhere in the world. Uranium and Thorium naturally decay into radium which further breaks down into radon gas. While some geographic areas have more radon than others, the only way to determine a building's radon level is to test 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 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.

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.



## 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 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.

## 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.

### **The level of radon in a building depends on:**

1. The concentration of uranium and radium in the soil or underlying geology;
2. How easily the radon can be transported into the building through the soil permeability, pathways and openings into the building;
3. 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);
4. How air is transported within a building;
5. The ventilation rate of the building.

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. 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.

### **Radon transport through soil to building requires:**

1. A driving force – A force that draws or pushes the radon toward the building.
2. A pathway to the home or building – High soil permeability, utility trenches, etc...
3. Openings in the foundation – Joints, cracks, earthen areas, utility penetrations, etc...
4. Buildings can create vacuums that will draw in soil gas.
5. These vacuums are very small and are referred to as air pressure differentials

## **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.

## **Other Routes of Entry**

### **Physical Penetrations and Building Materials**

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.

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.

## **Heating Ventilation and Air Conditioning**

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.

## **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](http://www.healthoregon.org/wells).



## ENVIRONMENTAL FACTORS INFLUENCING 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.

### Determining Testing Locations

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.*

### Plan Testing Requirements

1. All frequently occupied rooms will be tested simultaneously.
2. Examples include: offices, classrooms, conference rooms, gyms, auditoriums, cafeterias & break rooms.
3. 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, passive devices will 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 electrostatically 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:**

1. 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).
  - a. 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.
2. The electret is removed from the chamber and its voltage is measured with a specialized reader both before and after the measurement period.
3. 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:**

1. Results can be given immediately
2. Does not require power
3. Can be reused after reading the voltages

**Disadvantages:**

1. Sensitive to background radiation
2. Sensitive to altitude
3. Voltage measurements should be done at the same temperature
4. 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.

**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.

## 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 will be used when testing for radon in school buildings. The following steps will be taken:

### Step 1: Initial Measurements

Initial measurements will be short-term measurements of 2-7 days, and will 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 will be placed during colder months (October through March, depending on geographical location).

1. An assessment of the building will 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 will 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 will 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 accomplished in a timely manner.

## 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 will 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 will 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 will 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 will be fixed (lowered).

[A great difference in the results of the short-term tests may indicate a flaw in the testing process, and will 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 will be done.]

All follow-up measurements in will be conducted simultaneously. Follow-up measurements will 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.

## **Mitigation**

Mitigation will be conducted depending 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>

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.

## **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 Active Soil Depressurization (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.

## **Types of Test Kits Used in Quality Assurance for Radon Testing**

St. Mary’s Academy will use the following forms of Quality Assurance during the testing procedures for the School/District Building/s

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 will be conducted.

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.

Blanks at a rate of 5 percent of the rooms to be tested at a school site minimum.



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.

A minimum of 3 percent of the rooms to be tested at a school site will have spikes.

A device placement and floor plan will be developed for each school building to be tested. The serial numbers and location of devices will be placed on the site plan, device log and chain of custody

1. The School Radon Measurement Team will calculate how many detector kits are needed to ensure that a 1 sampling device per 2000 SF of building are conducted.
2. In addition to those detectors, kits for Quality Assurance (QA) purposes will 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 will be 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 will 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.

## INTERPRETATION OF RESULTS

### Initial Results

1. Review the results of the initial testing, 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).

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

If results are:	Expected	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, the district team will contact the radon measurement lab to investigate the situation further. The district may retest that the room associated with the questionable duplicate. If the lab doesn't provide a satisfactory answer, a team representative should contact a Radon Measurement Professional/Districts Consultant to discuss.

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 will contact a Radon Measurement Professional/Districts Consultant to discuss.
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.

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

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

### Spike Testing Results and Their Application

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.

A trend in RPE values that are more than  $\pm 30\%$  will be investigated. The Team's storage, handling, and kit placement should be reviewed. At the same time, the Radon Measurement Lab will be contacted and the RPE result(s) discussed so that the Lab can review its own procedures.

**Relative Percent Error (RPE) Table**

Between +10% and -10%	Expected Range of Variability
Between +20% and -20%	In Control
Between +30% and -30%	Warning
Outside +30% and -30%	Out of Control

**RADON TESTING PROCESS PLAN**

The first step of to be conducted by the district (initial screening measurements) will be 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** will be prepared for each school/building 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 will 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](http://www.nrpp.info)) or the National Radon Safety Board (NRSB, [www.nrsb.org](http://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) will 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.
4. Added to this number will be the test kits needed for Quality Assurance purposes.
5. Test kits will 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.
6. Testing will occur during the time that students and teachers are normally present (during weekdays).
7. In addition to placing detectors, additional test kits will 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) will 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 will 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 will be 20 inches to 6 feet above the floor, at least 1 foot below the ceiling.

10. Test kits will **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 will 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 will 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 will 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 will 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  $\frac{3}{4}$  inch diameter hail and may produce tornadoes.
13. Test Kits will 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, the testing will be conducted on weekdays. The actual length of time a kit is deployed depends on the manufacturer's instructions.

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 will 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 will be functioning.
19. No initial measurements will be conducted 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) will 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 Testing 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/Districts Consultant.

### **Report and Distribution of Results**

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 will be directed to a Radon Measurement Professional/Districts Consultant.

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](http://www.nrpp.info) and [www.nrsb.org](http://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.

School administration will 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, then additional steps will be taken to mitigate Radon Levels at the site.

Initial testing will 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. The district will test schools once every 10 years regardless of initial testing results or whether mitigation was done.

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.

 Environmental Professional 10/21/19  
Signature/title Date

MAIL TO: Oregon Radon Awareness Program  
800 NE Oregon St, Suite 640  
Portland, OR 97232-2162

EMAIL TO: [radon.oregon@state.or.us](mailto:radon.oregon@state.or.us)

22



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**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 is 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**  
**Site Plans**  
**Signage**

## Appendix A: Test Kit Placement Guide

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

a. 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.

b. 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 place the test kit on the teacher’s desk or up (out of the way of students) on a bookshelf.

c. 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.

d. 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.

e. 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* in OHA’s Testing for Elevated Radon in Oregon Schools.]

f. 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 of OHA's Testing for Elevated Radon in Oregon Schools.]

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

g. 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 same 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  
Historic Sampling  
Lab Reports  
Chain of Custody**

**Appendix C**

**Communications**

**Letter to Parents and Staff About Radon Measurements**

# KELSAY

## Environmental Consulting

DATE

To: School District xxxxx Parents/Teachers/Staff

Re: School District xxxxx **Radon Notification Letter (Example)**

Dear Parents, Teachers and Staff,


The following communication to students, parents and staff information is associated with environmental testing and inspections conducted during the (calendar year xxx).

School District xxxxx has begun to put into action a Radon Protocol and Plan as required by recent state regulations. Toward that effort, an initial screening for radon was conducted by Kelsay Environmental. Radon testing was conducted on the lower floors of the building as indicated in the sampling guidelines. All samples were short duration samples and were conducted during the fall/winter.

None of the samples returned a result higher than 0.5 picocuries/Liter (p/l), the EPA action level for radon is 4.0. Per the Protocol and Plan additional long-term sampling will be conducted to confirm these preliminary results. However, no indications of high Radon levels were indicated from the initial screening.

If you have any questions related to this notice, please contact me at 503-705-0514.

Sincerely,



Brad Kelsay  
Project Manager/Industrial Hygienist  
Kelsay Environmental



**Appendix D**  
**OREGON RADON RULES ORS 332.166-167**

Oregon Revised Statutes- Radon in Schools.

332.166 Provision of information to school districts about elevated levels of radon. (1) The Oregon Health Authority shall disseminate information related to elevated levels of radon to each school district in this state. Information disseminated under this section must include:

- (a) Information about radon and the dangers associated with elevated levels of radon;
- (b) The level of radon at which the United States Environmental Protection Agency recommends schools take action to reduce indoor radon concentrations;
- (c) Processes by which schools may be tested for elevated levels of radon; and
- (d) Model plans developed pursuant to ORS 332.167.

(2) Dissemination of information under subsection (1)(c) of this section must take into account industry standards for testing buildings for elevated levels of radon.

(3) Upon request, the State Board of Education shall assist the authority in disseminating the information described in this section. Dissemination of information may occur by any reasonable means, including posting the information on a website maintained by the authority or the Department of Education and providing each school district with instructions on how to access the information. [2015 c.729 §1]

332.167 Tests of schools for elevated levels of radon; plan; results. (1) A school district shall develop a plan for testing schools for elevated levels of radon. At a minimum, plans developed under this subsection must:

(a) Provide for the testing of radon in any frequently occupied room in contact with the ground or located above a basement or a crawlspace; and

(b) Provide for the testing of radon in a school at least once every 10 years.

(2) The Oregon Health Authority shall develop model plans for school districts to follow in implementing the requirements of this section. The authority shall seek the input of the Oregon School Boards Association in developing the model plans.

(3) Results of a test performed under this section must be:

(a) Provided to the district school board;

(b) Provided to the authority in a manner prescribed by the authority; and

(c) Made readily available to parents, guardians, students, school employees, school volunteers, administrators and community representatives at the school's office or school district's office or on a website for the school or school district.

(4) Information provided and made available under subsection (3) of this section must include the level of radon at which the United States Environmental Protection Agency recommends schools take action to reduce indoor radon concentrations. [2015 c.729 §2]

Note: Section 3, chapter 729, Oregon Laws 2015, provides:

Sec. 3. (1) A school district shall submit the plan developed under section 2 of this 2015 Act [332.167] to the Oregon Health Authority on or before September 1, 2016.

(2) Notwithstanding section 2 (1)(b) of this 2015 Act, plans developed under section 2 of this 2015 Act shall require initial testing of schools for elevated levels of radon on or before January 1, 2021.

(3) Subsection (2) of this section does not apply to any school that has been tested for elevated levels of radon on or after January 1, 2006. [2015 c.729 §3]

Note: See note under 332.166.