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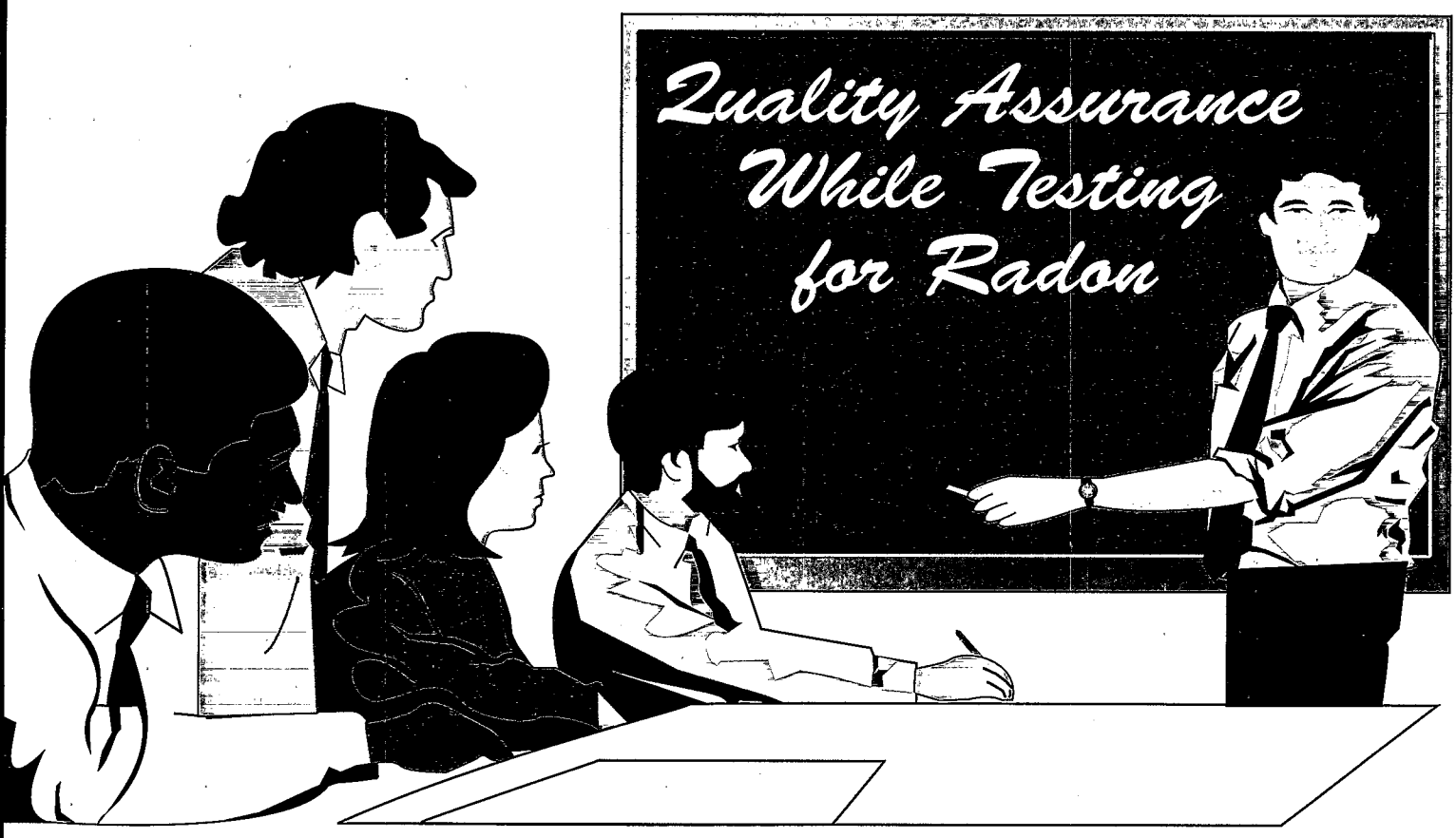
RADON MEASUREMENT IN SCHOOLS

National Radon Training Centers

Self-Paced Training Workbook



402B94001

Radon Measurement in Schools:
Self-Paced Training Workbook

This workbook was developed by the University of Minnesota's
Midwest Universities Radon Consortium (MURC) and
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who were instrumental in developing this workbook.

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Preface

The Audience for this Workshop

This workbook is designed for an audience of school officials - including school administrators, business officers, facility managers, health and safety officers - as well as maintenance and operations staff.

Completion of this training and workbook satisfies EPA's recommendation for training of school personnel who plan to conduct a radon test in schools using measurement devices that are returned to a RMP-laboratory for determination of the test result (see page 13 "Recommended Level of Training" in EPA's Radon Measurement in Schools - Revised Edition).

The Purpose of this Workbook

To provide trainees with experience in planning a radon test, interpreting test results, implementing quality assurance during testing, and documenting the testing process for a school building.

Reference for this Workbook

This book encourages trainees to apply the information contained in EPA's guidance document "Radon Measurement in Schools - Revised Edition." As a result, *each trainee should have a copy of EPA's testing guidance entitled Radon Measurement in Schools - Revised Edition* (EPA 402-R-92-014) when using this workbook. The testing guidance should serve as reference for this workbook. For more detailed information, refer to the testing guidance or contact your State Radon Office.

EPA's "Radon Measurement in Schools - Revised Edition" is the companion document for this workbook.

The Method of Presentation

Each unit in this workshop is prefaced by a unit overview and a list of participant objectives. Each of the objectives relates to a segment of the unit. Text containing highlights of the testing procedure are broken up with exercises and activities. Some of these activities are fill-in-the blank questions while others require the application of information contained in EPA's testing guidance entitled Radon Measurement in Schools - Revised Edition (EPA 402-R-92-014). *Answers to each activity can be found at the end of each unit.* These activities help to reinforce the information presented in each segment of the workbook and

Before testing your school, contact your State Radon Office for any state requirements on radon testing in schools.

If you have any questions while working through this document, contact your State Radon Office or EPA Regional Office (see EPA's document Radon Measurement in Schools - Revised Edition for a list of phone numbers).

provide an opportunity for trainees to discuss with the instructor, State Radon Office, or EPA Regional Office any problems or questions arising from the activities. The notes and completed activities in this workbook will provide a review of radon testing in school buildings for each trainee.

To make this workbook as useful as possible, trainees are encouraged to bring a floor plan or emergency plan of the school they plan to test for radon. If the floor plan that was used to construct the school is unavailable, design one by hand making sure to include information on the foundation type (e.g., slab-on-grade, crawl space, or basement) underlying each building of your school and a room number/name of each room on the floor plan. This floor plan will enable you to initiate the planning stage of testing in your school building during your training.

Developing a Plan for Providing Information

Before placing radon detectors in schoolrooms, notify school staff and students about what to expect during the testing process and provide educational materials on radon before the testing period begins. Your State Radon Office may have educational materials developed specifically for students or may be able to provide you with copies of *EPA's Citizen's Guide to Radon* to distribute to school personnel. Notifying students and teachers prior to testing may help reduce unnecessary handling of detectors during testing. You may also want to display a sample detector in your school's administrative office so that teachers, other school staff, and students can examine and become familiar with the detector's appearance.

If possible, provide test results after follow-up testing has been completed and the quality assurance measurements have been evaluated. The complete test results are needed before determining whether or not action needs to be taken to reduce radon. This information can then be used by the appropriate school official to develop a communication plan to release the test results or to prepare for any other further action. School officials should also communicate to school staff and parents the school administration's plan to reduce any elevated radon level.

Training for School Mitigation

The EPA has sponsored workshops for training school officials and others on how to reduce radon in schools. Information on these and other training programs is available through your EPA Regional Office or State Radon Offices. Phone numbers for these can be found on pages 28 - 30 of EPA's Radon Measurement in Schools - Revised Edition (EPA 402-R-92-014).

UNIT 1

Introduction to Radon in Schools

Unit Overview

This unit begins the process of getting to know radon in schools. It lays the basis for the workbook by:

- Defining radon.
- Describing how exposure to radon increases the risk of cancer.
- Describing how radon enters schools.

The unit describes the three main factors that affect one's risk due to radon, and the EPA estimates of how many people may die each year from lung cancer due to radon exposure.

The research that EPA has done on radon in schools across the country is described to provide some perspective on the extent of the problem. The unit concludes by discussing three factors that EPA has found to be critical in determining why some schools have elevated radon levels and others do not.

For more information on the issues presented in this unit, see Section I (pages 1-5) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

Participant Objectives

After the completion of this unit, participants will be able to:

- Briefly define radon, where it comes from, and how it enters buildings.
- Cite the units for measuring radon and its decay products.
- Cite several factors that affect one's risk from lung cancer due to radon exposure.
- Cite several factors for why radon concentrations are high in some buildings and low in others.

Radon Facts

What is radon?

Radon is a naturally-occurring radioactive gas. It comes from the natural breakdown, or radioactive decay, of uranium. Uranium is found in soils and rocks all across the U.S. When uranium decays, it eventually breaks down into radon, which is a gas that can move through the soil and into buildings through cracks and openings in the foundation. Radon is also radioactive and breaks down into *decay products* that may become trapped in your lungs when you breathe. These decay products are also radioactive and release small bursts of radiation when they break down. This radiation can damage lung tissue and lead to lung cancer over time.

Radon is colorless, odorless, and tasteless. The only way to know whether or not there is a high level of radon in a school building is to test the school for radon.

What are the units of pCi/L and WL?

The concentration **of radon gas** in the air is measured in units of picocuries per liter (pCi/L). Radioactivity can be assessed in terms of the number of decays per minute, and one picocurie per liter means that there is enough radon in one liter of air to produce 2.2 "decays" per minute. In a classroom that is 30 ft. x 30 ft. x 8 ft. high, approximately 450,000 decays per minute would occur for each picocurie of radon. Sometimes test results are expressed in *working levels* (WL) representing the decay products of radon.

Studies have found that radon concentrations in the outdoor air average about 0.4 pCi/L. Inside buildings radon and decay products can build up to higher concentrations.

What is the EPA "action level?"

EPA recommends that schools *take action to reduce the level of radon* when levels are 4 pCi/L or higher. If a room is found to have a level of 4 pCi/L or greater after initial testing, this measurement should be confirmed with a follow-up test. If the initial and follow-up test indicate that the radon level is at or above 4 pCi/L, you should take action to reduce the radon level below 4 pCi/L.

For additional information on radon facts, see Section I.A (page 2) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

Activity 1-1

Fill in the blanks or answer the following questions.

1. Radon is a _____, _____ gas.

2. Radon comes from _____ which is found in rocks and soils all across the United States.

3. Radon is a _____, so it can move from the soil and rock to the interior of buildings through small openings.

4. Radon decays into _____ that can become trapped in your lungs.

5. How can I tell if there are high levels of radon in my school?

6. What are the units for measuring radon?

7. What are the units for measuring radon decay products?

If you have trouble answering a question, refer to the answers at the end of the unit.

Health Risks of Radon

How does radon cause lung cancer?

Radon is a known to cause cancer in humans. The radiation given off by the decay products inside your lungs can damage the cell lining of your lungs and lead to lung cancer over the course of your life time.

An individual's risk of getting lung cancer from radon depends mostly on three factors:

1. how high a level you are exposed to.
2. how long you are exposed.
3. whether you smoke.

The risk from radon increases with the level and length of time to which you are exposed. Smoking combined with radon is an especially serious health risk.

For additional information on the health risks of radon, see Section I.B (pages 2-4) of the EPA guidance document "Radon Measurement in Schools - Revised Edition."

How does radon compare to other risks?

EPA estimates that radon may cause about 14,000 lung cancer deaths in the United States *each year* (because of the uncertainties, the actual number could range from 7,000 to 30,000 deaths *each year*).

The U.S. Surgeon General has warned that radon is the second-leading cause of lung cancer deaths. Only smoking causes more deaths from lung cancer.

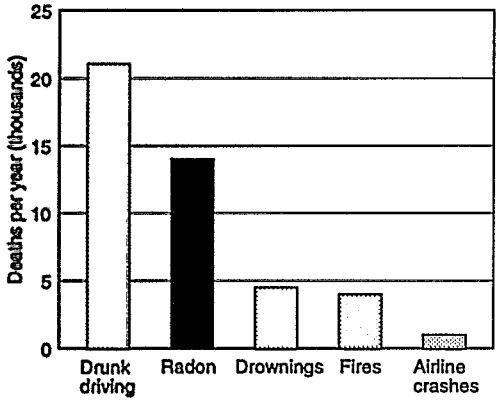


Figure 1-1: The numbers of deaths from various causes (taken from 1990 National Safety Council reports).

Is radon more of a concern for children?

There is some evidence that children are at greater risk than adults for certain types of cancer from radiation, but there are currently no conclusive data on whether children are at greater risk from radon than adults.

Radon Exposure

Is radon a problem in homes?

The risk from radon increases with the amount of time you spend breathing it in. Because most people spend most of their time in their homes, radon in the home is likely to be the most significant source of radon exposure. Parents are strongly encouraged to measure their homes for radon, and to take action to reduce elevated radon concentrations. EPA has

several reports designed to help people understand how to test their homes for radon, including *A Citizen's Guide to Radon* (EPA 402-K92-001, May 1992), available from State and EPA Regional Offices listed in the appendices in "Radon Measurement in Schools—Revised Edition."

Is radon a problem in schools?

For most school children and staff, the second largest contributor to their radon exposure is likely to be their school. Therefore, EPA recommends that school buildings be tested for radon and the levels be reduced to below EPA's action level of 4 pCi/L.

Activity 1-2

1. There are three main factors that affect one's risk from lung cancer due to radon exposure. These are:

   A. _____ a level you are exposed to.

   B. _____ you are exposed.

   C. Whether you _____.

2. What is the estimate for the number of lung cancer deaths due to radon each year in the United States?

3. What is the one factor that causes more lung cancer deaths than radon?

4. How do annual deaths from radon compare with annual deaths from drunk driving, drownings, fires, and airline crashes?

Testing for Radon and Taking Action

If high radon levels are found, what can be done about it?

The EPA action level of 4 pCi/L for radon gas (0.02 WL, for decay products) means that if any room is found to have a level of 4 pCi/L or higher, a second follow-up test should be conducted. If the initial and follow-up tests indicate that the radon level is equal to or above 4 pCi/L, the school should take action to lower the level to below the action level. More information about radon reduction in schools is available from EPA's guide "Reducing Radon in Schools: A Team Approach (EPA 402-R-94-008)."

Are concentrations less than the action level safe?

The action level of 4 pCi/L (or 0.02 WL) is based largely on the ability of current technologies to reduce radon levels to this point. It does *not* mean that levels less than 4 pCi/L are safe. Any exposure to radon carries *some* risk, but the lower the exposure—in terms of time and concentration—the lower the risk.

Should we reduce radon levels as low as possible?

Radon concentrations depend on many factors. In general, mitigation contractors will work to reduce radon levels to as low as feasible, but reducing levels to zero is impossible. To a certain extent, this is because radon exists even in outdoor air at a level of about 0.4 pCi/L. It becomes diluted as it rises from the soil, so it is usually in very low concentrations outdoors.

What has been found so far about radon in schools?

Refer to Section I.D (page 4-5) of the EPA guidance document "Radon Measurement in Schools—Revised Edition" for more information on the radon problem in schools.

Based on a national EPA survey of radon in schools, EPA estimates that nearly one in five U.S. schools have at least one frequently occupied ground contact room with a short term radon level above 4 pCi/L. Other EPA studies in schools have found schools with levels well over 20 pCi/L and some have been found with levels over 100 pCi/L. *For additional information on the radon problem in schools, See Section I.D. (pages 4-5) of the EPA guidance document.*

Are the radon levels similar in buildings or homes in the same geographic area?

Buildings that are side by side can have very different levels of radon, so it is impossible to know what radon levels are without testing.

Activity 1-3

Answer the following questions.

1. Are there any states where we can be sure there is no radon?

2. What are the highest radon concentrations that have been found in schools?

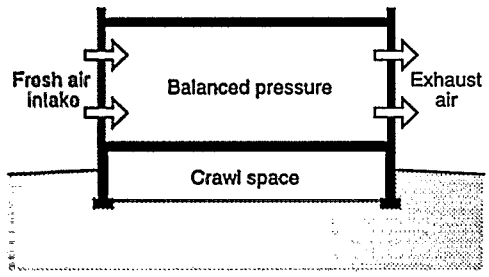


Figure 1-2: If properly designed, mechanical ventilation can dilute indoor radon concentrations.

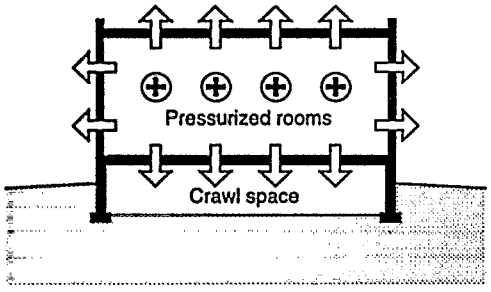


Figure 1-3: Mechanical ventilation can be designed to pressurize the interior spaces in a building by bringing in outdoor air. This may help reduce radon entry by pressurizing the building and diluting radon.

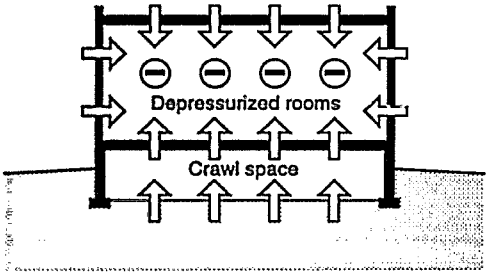


Figure 1-4: Some mechanical ventilation systems are not properly balanced resulting in depressurization of the interior spaces in a building. This can induce radon to enter spaces and must be addressed in a mitigation effort.

Mechanisms of Radon Entry

How does radon enter schools?

There are three factors that determine why some schools have high radon levels and others do not. These are:

1. **The soil under the school**
   - The radon concentrations in the soil (source strength).
   - How easily the radon can move through the soil (soil permeability).
2. **The structure and construction of the school**
   - Many schools are constructed on adjoining floor slabs which permit radon gas to enter through construction and expansion joints between the slabs. Other features, such as basements, crawl spaces, utility tunnels, sub-slab HVAC ducts, cracks, or other penetrations in the slab (e.g., around pipes) also are places where radon can enter a building.
3. **The type, operation, and maintenance of the HVAC system**

   For example, the heating, ventilating, and air conditioning (HVAC) systems can:
   - Dilute indoor radon levels by bringing in outdoor air—i.e. ventilating (see Figs. 1-2 and 1-3).
   - Allow radon to build up because of decreased ventilation.
   - Keep radon out by pressurizing a building (see Fig. 1-2 and 1-3).
   - Draw radon inside a building through the foundation by depressurizing a building (i.e., creating a negative air pressure within a building by exhausting indoor air—see Fig. 1-4).

   How well and how often HVAC systems undergo maintenance is also important. For example, if air intake filters are not cleaned and changed periodically, the amount of outdoor air coming in can be reduced. Less ventilation means that radon will build up inside.

Activity 1-4

Answer the following questions or fill in the blanks as appropriate:

1. There are three factors that determine why some schools have high radon levels while others do not. These are:

   A. The _____ under the school. What two properties of this are important?

   B. The _____ of the school.

   C. The type, operation, and maintenance of the _____.

2. If a school room had an exhaust fan operating, what effect would this have on the air pressure inside a school room? What effect would this have on the radon level for that room if the room is in contact with the soil? (NOTE: an exhaust fan draws air within a school room and vents it to the outdoors.)

3. In order to save energy, some schools have reduced or restricted the intake of outdoor air by their HVAC system. What effect would this have on radon concentrations? Explain how this effect occurred.

Refer to Section I.E (page 5) of the EPA guidance document "Radon Measurement in Schools—Revised Edition" for more information on how radon enters schools.

If you have trouble answering a question, refer to the answer at the end of the unit for a discussion of the answer.

Unit Summary—Introduction to Radon in Schools

This unit reviews:

- The definition of radon as *a naturally-occurring radioactive gas, originating from uranium found in nearly all rocks and soils that moves upward through cracks and openings in the foundations of buildings.*
- The definition of decay products as *the radioactive products of radon that can become trapped in lungs, releasing small bursts of radiation, which can damage lung tissue and lead to cancer.*
- The definitions of picocuries per liter (pCi/L) and Working Levels (WL).
- The EPA "action level" of 4 pCi/L (0.02 WL).
- The three main factors that determine risk from radon exposure: 1) the concentration; 2) the duration of exposure to that concentration; and 3) smoking habits.
- The EPA estimates of about 14,000 lung cancer deaths *each year* in the United States due to radon exposure.
- The findings of the research that EPA has done on radon in schools, with the results showing that 19.3% of schools have elevated radon levels.
- The three factors that determine why some schools have high radon levels and others do not: 1) the characteristics of nearby soil; 2) the structure and construction of the school; and 3) the type, operation, and maintenance of the heating, ventilating, and air conditioning (HVAC) system.

Correct Answers for Activity 1-1

Fill in the blanks or answer the following questions.

1. Radon is a ___*naturally-occurring, radioactive , colorless, odorless, tasteless*___ gas.
2. Radon comes from ___*uranium*___ which is found in rocks and soils all across the United States.
3. Radon is a ___*gas*___, so it can move from the soil and rock to the interior of buildings through small openings.
4. Radon decays into ___*radon decay products*___ that can become trapped in your lungs.
5. How can I tell if there are high levels of radon in my school?

   Test your school

6. What are the units for measuring radon?

   picocuries per liter (pCi/L)

7. What are the units for measuring radon decay products?

   working levels (WL)

Correct Answers for Activity 1-2

Answer the following questions.

1. There are three main factors that affect one's risk from lung cancer due to radon exposure. These are:

   A. ___*how high*___ a level you are exposed to.

   B. ___*how long*___ you are exposed.

   C. Whether you ___*smoke*___.

2. What is the estimate for the number of lung cancer deaths due to radon each year in the United States?

   14,000

3. What is the one factor that causes more lung cancer deaths than radon?

   Smoking

4. How do annual deaths from radon compare with annual deaths from drunk driving, drownings, fires, and airline crashes?

   Annual deaths from radon are second only to deaths from drunk driving in this list. Radon causes more deaths each year than drownings, fires, and airplane crashes.

Correct Answers for Activity 1-3

Answer the following questions.

1. Are there any states where we can be sure there is no radon?

   No; elevated levels have been found in every state.

2. What are the highest radon concentrations that have been found in schools?

   Results of over 100 pCi/L have been found in schools.

Correct Answers for Activity 1-4

1. There are three factors that determine why some schools have high radon levels while others do not. These are:

   A. The ___*soil*___ under the school.

   What two properties of this are important?

   The concentration or amount of radon in the soil.

   How easily radon flows through the soil—the soil permeability.

   B. The ___*structure and construction*___ of the school.

   C. The type, operation, and maintenance of the *HVAC system*.

2. If a school room had an exhaust fan operating, what effect would this have on the air pressure inside a school room? What effect would this have on the radon level for that room if the room is in contact with the soil? (NOTE: an exhaust fan draws air within a school room and vents it to the outdoors.)

   Unless an equal amount of outdoor air is provided by your HVAC system to replace the indoor air that is exhausted by the fan, soil gas containing radon may be drawn into the room. The exhaust fan, in effect, is depressurizing the room.

3. In order to save energy, some schools have reduced or restricted the intake of outdoor air to their HVAC system. What effect would this have on radon concentrations? Explain how this effect occurred.

   Reducing the intake of outdoor air by your HVAC system may have two possible effects:

   First: If exhaust fans in the school building are operating, this could create a negative air pressure in the rooms of the school when there is no outdoor air to replace the indoor air that is exhausted from the school building (see Figure 1-4, page 8). The negative pressure in the school building will cause radon in the soil gas to move through foundation openings (e.g., cracks in the slab, expansion joints between the slab and wall) and into school rooms.

   Second: When reducing or restricting the flow of outdoor air into a school building, indoor air pollutants such as radon may build up. Since there is little or no outdoor air to dilute radon that entered the school, the radon concentration in school rooms may increase.

UNIT 2

Radon Measurement Strategy for Schools

Unit Overview

This unit is a core element of this training, because it presents critical definitions and the EPA school testing strategy. The unit covers:

- Short-term and long-term tests.
- The EPA measurement strategy.
- The interpretation of test results in terms of the need for mitigation.
- Retesting schools in years after the measurement program is complete.
- Radon testing program management.
- Measurement devices that are currently available for testing of different durations.

For more information on the EPA measurement strategy, see Section II.A and II.B (pages 6-9) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

Participant Objectives:

Upon completion of this unit, participants will be able to:

- Define long-term and short-term testing.
- Explain the EPA-recommended strategy for testing in schools, including initial and follow-up measurements, the action level, the interpretation of test results (in terms of the need for mitigation), and the guidance for retesting.
- Identify commonly-used testing devices for schools and whether they are appropriate for short-term or long-term measurements.
- Apply the radon testing strategy to a variety of school construction types, *and* to their own school(s).

To insure that the measurements you make are reliable, include Quality Assurance in your testing program—see Unit 5.

Purpose of the EPA Testing Strategy

The purpose of the measurement strategy is to provide school officials with a system for deciding on the need for mitigation. This strategy includes:

1. How to conduct a series of tests to measure radon levels in the school.
2. How to interpret the results and decide if corrective action to reduce radon levels is necessary.

Use detectors from a laboratory that is listed with EPA's Radon Measurement Proficiency (RMP) Program or state certified—contact your State Radon Office for more information.

Short-term and Long-term Testing

Radon can be measured over different time periods ranging from two days to a year (radon concentrations can actually be measured over a few minutes, but those types of measurements are not useful for determining the need for mitigation). Tests are categorized as either *short-term* or *long-term* depending upon the number of days the devices are used in the school.

Short-term tests are defined as any test that is two to 90 days in length.

Long-term tests are defined as any test lasting longer than 90 days.

Short-term tests measure radon for a period as short as two days, for some devices, or as long as 90 days for other types of devices. A short-term test is the quickest way to measure for radon. Because radon levels tend to vary from day to day and from season to season, a short-term is less likely than a long-term test to give an average radon level for a school year. Short-term tests must be made over a period of at least 48 continuous hours (back-to-back without interruption).

Long-term tests measure radon over a period longer 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 school room than a short-term test.

For more information on short- and long-term testing, see Section II.A (pages 6-7) of the EPA guidance document "Radon Measurement in Schools—Revised Edition".

Measurement Devices

All devices used for measuring radon in schools should meet the EPA's Radon Measurement Proficiency Program (RMP) or State certification program requirements. Information on the manufacturer and whether they are RMP-listed for that device type can be obtained from your State Radon Contact or EPA Regional Office (see the EPA guidance document for phone numbers). *It is critical to ensure that the supplier of the devices is listed as having met the EPA RMP (and any additional State) requirements for that device.*

Some devices may require the use of an analytical laboratory, and some provide the test results directly to the person operating the equipment. ***Keep in mind that if the results from the devices are read directly by school personnel without the use of an analytical service, those personnel should successfully participate in the EPA RMP or any comparable State certification program.***

Three of the most common types of radon measurement devices are:

- **Activated Charcoal (AC) and Charcoal Liquid Scintillation (CLS) Detectors:** These are used to make short-term measurements
- **Electret Ion Chambers (EIC):** There are two different types of Electret Ion Chambers—one can be used for short-term and the other for long-term measurements. If you use the electret reader to determine the radon level measured by the EIC, you should demonstrate proficiency in the measurement of radon via EPA's Radon Proficiency Programs.
- **Alpha Track Detectors (ATD):** These are used for both short-term and long-term measurements.
- **Continuous Radon Monitors:** These devices may be used for short-term or long-term measurements. These devices measure radon gas. Since results can be read directly by school personnel without the use of an analytical service, you should demonstrate proficiency in the measurement of radon via EPA's RMP Program.
- **Continuous Working Level Monitors:** These devices may be used for short-term or long-term measurements. These devices measure radon decay products. Since results can be read directly by school personnel without the use of an analytical service, you should demonstrate proficiency in the measurement of radon decay products via EPA's RMP Program.

For more information on measurement devices, see Appendix D (page 34) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

When you receive your measurement devices in the mail, read the manufacturer's instructions before using them.

After being opened and exposed to indoor air, activated charcoal detectors (AC) and charcoal liquid scintillation detectors (CLS) should be mailed to the lab analyzing the detectors within a day after the test is completed. Make sure the exposed detectors will reach the lab within 2 to 3 days.

Consult the answers at the end of the unit if you are having difficulty answering a question.

Activity 2-1

Answer the following questions or fill in the blanks.

1. Short-term tests measure radon for as short as _____ days and as long as _____ days.

2. Long-term tests measure radon for longer than _____ days.

3. Name five types of measurement devices most often used to make short-term radon measurements.

4. Name two types of measurement devices most often used to make long-term radon measurements.

5. If you were going to conduct a 2-day or a 4-day short-term test, which devices could you use?

6. Which devices may be used for a 2-week or 8-week short-term test?

7. If an EIC or ATD is designed for a 6-month long-term test, can it be used for a 1-month short-term test?

Measurement Strategy

If a school decides to use a short-term test during initial measurements, EPA recommends the two step approach described below.

Step 1 Initial Measurements

- Take initial measurements using a short-term test.

Short-term measurements should be made in *all frequently-occupied rooms in contact with the ground* to determine whether or not elevated radon concentrations are present. *All rooms should be tested simultaneously (i.e., on the same day).*

Step 2 Follow-up Measurements

- Do a follow-up test in every room with a short-term, initial test result of 4 pCi/l or greater.

All follow-up measurements in a school 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*). This will ensure that the two results are as comparable as possible.

- *Use a short-term, follow-up test* if results are needed quickly.

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 EPA's radon action level (e.g., about 10 pCi/L or higher), a short-term follow-up measurement should be taken immediately.

- *Use a long-term, follow-up test* to better understand the average radon level for a school year.

When a room's initial result is only slightly above about 4 pCi/L (i.e. between 4 and 10 pCi/L), a long-term follow-up measurement—preferably taken over the entire (e.g. nine months) school year—is appropriate. The result from such a test may best represent the average radon concentration for the school year in that room. A long-term test should be conducted over the school year immediately following the completion of initial measurements.

HVAC OPERATION &TESTING

During both initial and follow-up testing, the HVAC system should be operating as it normally does. It is not necessary to change the operation of the HVAC system when testing for radon.

The decision to mitigate should not be based on one initial measurement.

If there are any rooms with initial results of 10 pCi/L or greater, then consider doing all short-term follow-up tests in that school even though there may be rooms just slightly above 4 pCi/L. This approach streamlines your follow-up testing and simplifies record keeping.

HELPFUL FLOWCHART:

The recommended measurement and decision-making strategy is presented as a flow chart on page 17 in the EPA guidance document, "Radon Measurement in Schools - Revised Edition."

Follow-up testing helps to verify your initial test result. Never base your decision to mitigate on just the initial test result. Problems in the laboratory procedures when analyzing the detectors or problems in the testing process may have affected your test results.

Deciding on the Need to Mitigate

The EPA does not recommend that schools use a single short term test as the basis for determining the need for mitigation.

- If a short-term test was used for the follow-up measurement, *average the initial and follow-up test results for each room, and if that result is 4 pCi/L or greater, mitigate in that room or area.*
- If a long-term test was used for a follow-up test, *use the result from the long-term follow-up test, and if that result is 4 pCi/L or greater, mitigate in that room or area.*

Deciding How Quickly to Mitigate

Very high radon levels (around 10 pCi/L or greater) demand a quicker response than levels closer to 4 pCi/L. If a level is near 100 pCi/L or greater, school officials should call their State Radon Contact.

RADON MITIGATION

If your school needs to mitigate one or more rooms, follow the recommendations in EPA's document "Reducing Radon in Schools: A Team Approach" (EPA 402-R-94-008).

Retesting

1. Retest some time in the future all frequently occupied rooms that have ground contact when the initial tests showed a radon level less than 4 pCi/L.
2. Retest yearly all school rooms that were mitigated.
3. Before major renovations are planned. Consider retesting to see if levels are 4 pCi/L or greater so that radon-resistant features can be built into the renovation.

   When renovating, consider the following.

   - If the renovation is structural or involves a major change to the HVAC system, radon testing should be conducted for the school building.
   - If the results of those radon tests are 4 pCi/L or greater, radon-resistant features should be incorporated in the renovation (see *Radon Prevention in the Design and Construction of Schools and Other Large Buildings (EPA-625-R-92-016).*
   - Test after the renovation.

RADON PREVENTION

If your school district is planning new school construction and/or renovations, consider following the recommendations described in the document Radon Prevention in the Design and Construction of Schools and other Large Buildings (EPA-625/R-92/016) .

Activity 2-2

1. You just received the results from your initial test. Given the initial test results of the five rooms that have radon levels greater than or equal to 4 pCi/L, what type of test (short or long-term) would you choose for follow-up testing?

   Suggestion: use the initial portion of the decision-making flow chart on page 17 of the EPA guidance document to guide your decision with each room.

Room #	Initial Measurement	Action
103	5.0 pCi/L	_____
111	4.5 pCi/L	_____
120	11.0 pCi/L	_____
131	15.0 pCi/L	_____
151	4.1 pCi/L	_____

2. If you have conducted an initial test for a room and found the level to be 20 pCi/L, would you:

   A. mitigate this room? or

   B. take another measurement in this room to confirm the initial measurements?

3. You made a 5-day, initial measurement using an activated charcoal device and found the radon level to be 12 pCi/L. When performing a follow-up measurement, what would be the length of your follow-up measurement? What type of measurement device would you use? Explain each of your answers.

Activity 2-3

1. The five rooms in Activity 2-2 have been retested with short term follow-up tests. The follow-up results are listed below. Which of these rooms should receive radon mitigation?

Room #	Initial	Follow-up	Action
103	5.0 pCi/L	3.0 pCi/L	_____
111	4.5 pCi/L	5.7 pCi/L	_____
120	11.0 pCi/L	9.5 pCi/L	_____
131	15.0 pCi/L	13.2 pCi/L	_____
151	4.1 pCi/L	3.0 pCi/L	_____

2. If you conduct initial testing in your school and you find that the initial test results indicate that most of the rooms tested have results less than 4 pCi/L except for one. The room above 4.0 pCi/L has a level of 4.2 pCi/L. What type of follow-up test (short or long-term) would you do? Why?

3. The initial test result for a room was 4.3 pCi/L. You've conducted the follow-up long-term test for this room and the result is 3.8. Should you mitigate this room?

   Suggestion: use the flow chart on page 17 of the EPA guidance document to help you determine if you need to mitigate.

Unit Summary—Radon Measurement Strategy for Schools

This unit presents key definitions:

- *Short-term tests* are defined as those lasting for two days or longer, but less than 90 days.
- *Long-term tests* are defined as those lasting for longer than 90 days.

The unit describes the differences between short- and long-term tests, and why one may be preferable over the other.

The *where* and *how* aspects of the EPA measurement strategy are reviewed in this unit.

- *Where* refers to testing in *all rooms that are frequently occupied and that have ground contact.*
- *How* refers to making *initial short-term measurements* in these rooms, then making *follow-up measurements* in those rooms with initial radon levels of 4 pCi/L or greater. Depending on the level of the initial short-term measurements, short-term or long-term tests may be used for a follow-up test.

This unit also presents the EPA recommendations for retesting schools after the original testing program (i.e. testing of all rooms that are frequently occupied and have some ground contact), and retesting prior to renovation.

Correct Answers for Activity 2-1

Answer the following questions or fill in the blanks.

1. Short-term tests measure radon for as short as ___2___ days and as long as ___90___ days.

2. Long-term tests measure radon for longer than ___90___ days.

3. Name five types of measurement devices most often used to make short-term radon measurements.

   Activated charcoal devices
   Alpha track detectors
   Electret ion chambers
   Continuous monitors
   Charcoal liquid scintillation detectors

4. Name two types of measurement devices most often used to make long-term radon measurements.

   Alpha track detectors
   Electret ion chambers

5. If you were going to conduct a 2-day or a 4-day short-term test, which devices could you use?

   Electret ion chambers, activated charcoal devices, charcoal scintillation devices, alpha-track detectors, or continuous monitors. Specific manufacturer's instructions need to be consulted—some types of these devices may be limited to a longer deployment time.

6. Which devices may be used for a 2-week or 8-week short-term test?

   ATD and Electret ion chambers. In some cases continuous monitors may be used for these long periods, although the cost may be very high.

7. If an EIC or ATD is designed for a 6-month long-term test, can it be used for a 1-month short-term test?

   While possible, significant adjustments would have to be made by the lab analyzing the detectors. Therefore, this practice is not recommeneded.

Correct Answers for Activity 2-2

1. You just received the results from your initial test. Given the levels of the five rooms that have radon levels greater than or equal to 4 pCi/L, what type of test (short or long-term) would you choose for follow-up testing?

   Suggestion: Use the initial portion of the decision-making flow chart on page 17 of the EPA guidance document to guide your decision with each room.

   There are two possible approaches for conducting a follow-up test for these initial results—both are appropriate.

   1st Alternative Approach

Room #	Initial Measurement	Action
103	5.0 pCi/L	*long-term*
111	4.5 pCi/L	*long-term*
120	11.0 pCi/L	*short-term*
131	15.0 pCi/L	*short-term*
151	4.1 pCi/L	*long-term*

   2nd Alternative Approach

   Let your highest initial test determine the duration of all your follow-up tests. Since Room 131 has 15.0 pCi/L, make all your follow-up tests short-term. This approach streamlines your follow-up testing and simplifies record keeping.

Room #	Initial Measurement	Action
103	5.0 pCi/L	*short-term*
111	4.5 pCi/L	*short-term*
120	11.0 pCi/L	*short-term*
131	15.0 pCi/L	*short-term*
151	4.1 pCi/L	*short-term*

2. If you have conducted an initial test for a room and found the level to be 20 pCi/L, would you:

   A. mitigate this room? or

   B. take a follow-up measurement in this room to confirm initial measurements?

   Answer B is correct.

3. You made a 5-day, initial measurement using an activated charcoal device and found the radon level to be 12 pCi/L. When performing a follow-up measurement to confirm this initial measurement, what would be the length of your follow-up measurement? What type of measurement device would you use? Explain each of your answers.

   Since the radon level for the initial measurement is several times the action level, conduct a short-term follow-up measurement. Ideally, the follow-up measurement should be five days in length and the detector should be the same type (i.e. activated charcoal device from the same manufacturer) used for the initial measurement. For short-term follow-up testing, maintaining consistency with your initial testing will help ensure that your initial test results are reproducible.

Correct Answers for Activity 2-3

1. The five rooms in Activity 2-2 have been retested with *short-term* follow-up tests. The follow-up results are listed below. Which of these rooms should receive radon mitigation?

Room #	Initial	Follow-up	Action
103	5.0 pCi/L	3.0 pCi/L	*mitigate*
111	4.5 pCi/L	5.7 pCi/L	*mitigate*
120	11.0 pCi/L	9.5 pCi/L	*mitigate*
131	15.0 pCi/L	13.2 pCi/L	*mitigate*
151	4.1 pCi/L	3.0 pCi/L	*consider mitigating*.*

If your initial and follow-up test results differ greatly (e.g. an initial test of 15.0 pCi/L and a follow-up test of 2.0 pCi/L), you may want to take a third test to verify your initial test result. It's possible that the large difference between the initial and the follow-up tests is a result of a detector failure.

Example calculation for Room 103:

$$\frac{5.0\ \text{pCi/L} + 3.0\ \text{pCi/L}}{2} = 4\ \text{pCi/L}$$

Since this is equal to 4 pCi/L (EPA's action level for radon) mitigate this room.

* Since there are health risks associated with levels below 4 pCi/L and you will be mitigating other rooms, consider reducing the level in Room 151.

2. If you conduct initial testing in your school and you find that the initial test results indicate that most of the rooms tested have results less than 4 pCi/L except for one. This room has a level of 4.2 pCi/L. What type of follow-up test (short or long-term) would you do? Why?

   A long-term test. Because the detected level is close to the action level of 4 pCi/L, a long-term test will provide a better estimate of the radon level for that room.

3. The initial short-term test result for a room was 4.3 pCi/L. You've conducted the follow-up long-term test for this room and the result is 3.8. Should you mitigate this room?

   Suggestion: use the flow chart on page 17 of the EPA guidance document to help you determine if you need to mitigate.

   The long-term test result is less than 4 pCi/L, so mitigation is not recommended if you adhere strictly to EPA's recommendation. However, since the level is close to 4 pCi/L and there are risks associated with levels below 4 pCi/L, consider mitigating the room.

UNIT 3

When to Measure Radon in Schools

Unit Overview

This unit describes when radon tests should be conducted, in terms of the:

- Seasons of the year
- Days of the week
- Building conditions
- Particular weather and HVAC system conditions

Participant Objectives

After completing this unit, participants will be able to:

- Identify seasons when testing is recommended.
- Identify the times during the week when testing is recommended.
- Describe the conditions that should be adhered to prior to and during testing.
- Cite at least two situations during which the EPA recommends that testing should *not* be conducted.

For more information on when to measure radon in schools, see Section II.D (pages 10-12) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

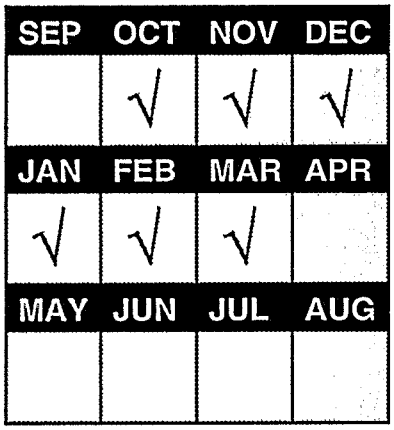


Figure 3-1: Initial measurements should be conducted during the colder months and when the school is occupied.

For additional information on why EPA recommends particular testing conditions, see Section II (D) on page 11 of the EPA guidance document: "Radon Measurement in Schools - Revised Edition."

Seasons When Schools Should Be Tested

The purpose of initial testing is to identify rooms that have the ***potential*** for high radon levels (above 4 pCi/L) during the school year.

Short-term tests should be conducted during the colder months of the year, when windows and external doors are likely to be kept closed. If you begin your initial test early—October or early November, you can begin follow-up tests (if necessary) during the remaining colder months.

Long-term tests may begin soon after the completion of the initial test and run up to the end of the school year. The school year is defined as the period when the school is fully occupied. Preferably, long-term tests should begin during the colder months of the school year for your geographic area.

Days of the Week When Radon Should be Measured

Short-term radon tests lasting between two and five days should be conducted on weekdays with the HVAC systems operating normally. For testing longer than 5 days, the testing should be conducted continuously over the testing period. For example, during the test period a radon measurement should not be discontinued and then recontinued at another time or date.

Conditions During Which Radon Should Be Measured

Short-term tests should be conducted when the building is as closed up as possible, with windows and exterior doors closed except for brief, normal entries and exits. This is called ***closed-building conditions***. If doors and windows are kept closed, there will be a minimum of outdoor air drawn into the room to dilute and lower the radon concentration. Also, depending on the differences in temperature between the inside and the outside air, wind direction, and wind strength, radon levels can vary greatly. Because of this, the EPA recommends that indoor radon levels be stabilized as much as possible by keeping doors and windows closed during the measurements.

Radon levels take some time to stabilize after closed-building conditions are in place. Tests lasting between two and five days should not begin until after closed-building conditions

have been in place for at least 12 hours. Tests lasting longer than five days are long enough so that the initial effect of high or low levels will not be significant.

A recommended strategy is to establish closed-building conditions during a weekend, and begin radon measurements on Monday morning.

Tests lasting up to 90 days are considered short-term tests and closed-building conditions should still be in place as much as possible. However, brief periods of open windows will not seriously jeopardize the results but should still be avoided.

When Tests Should Not Be Conducted

Testing **should not** be done:

- during major weather events such as high winds and/or heavy rains. Rapid changes in barometric pressure can affect radon levels.
- during the renovation of a school building, especially those involving structural changes, or during renovations of the HVAC systems. It is more appropriate to test prior to renovations and immediately after the completion of renovations. If elevated radon is present, radon resistant techniques can be included as part of the renovation.
- when the school is not in session or on long holidays when the HVAC system is "set back."

Prior to testing, review the weather forecast for the week, if you plan to make two- to five-day radon measurements.

Severe weather conditions do not affect long-term tests.

Activity 3-1

Fill in the blanks.

1. Short-term tests should be conducted during the _____ season, when windows and doors are generally kept _____.

2. Long-term tests can begin during any season, as long as the tests are conducted when the school is fully _____.

3. Short-term tests lasting 2-5 days should be conducted anytime during the days of _____ through _____ for at least _____ continuous hours.

4. Closed building conditions are when all _____ _____ are kept closed, except for brief _____.

5. There are two conditions when you should not test for radon. These are:

Activity 3-2

Answer the following questions:

1. You have scheduled a 4-day initial test during the first week of November. The weather forecast for that week is: heavy rains for Sunday, high winds with possible showers on Monday, sunny and clear for the remainder of the week except for a slight chance of late evening showers on Friday. When would you start and end the test? Explain your decisions.

2. EPA guidance recommends initial testing during the colder months of the school year (October to March). Keeping in mind that you may have to conduct follow-up tests, select the time period you will begin your initial testing. Consider the length of your initial test when making your decision.

3. You planned to conduct a 2-week initial test during the latter half of October. The weather forecast indicates that the weather will be unseasonably warm during this time of the month. Would you postpone testing given this information? Explain why you would/or would not postpone testing?

Unit Summary - When to Measure Radon in Schools

This unit presents the EPA guidance for when radon tests should be conducted. There are four major elements of the unit:

1. Initial tests should be conducted during the coldest months of the year when windows and doors are likely to be closed. During this time, radon levels are most likely to be stable.
2. The *days of the week* from Monday through Friday are recommended days for short-term tests lasting 2-5 days because the radon levels during the week are more representative of the levels to which school occupants are exposed. Short-term tests lasting longer than 5 days and long-term tests will extend over weekends.
3. The conditions that should exist during testing are *closed-building conditions,* which consist of keeping all windows and exterior doors shut except for brief entries and exits. In an effort to stabilize the radon levels, tests lasting less than five days should not begin until after at least 12 hours of closed-building conditions.
4. This unit discusses particular weather conditions during which radon tests should not be conducted, and presents EPA's recommendation not to measure radon during major school renovations.

Correct Answers for Activity 3-1

Fill in the blanks.

1. Short-term tests should be conducted during the ___*fall and winter heating*___ season when windows and doors are generally kept ___*closed*___.

2. Long-term tests can begin during any season as long as the tests are conducted when the school is fully ___*occupied*___.

3. Short-term tests lasting 2-5 days should be conducted anytime during the days of ___*Monday*___ through ___*Friday*___ for at least ___*48*___ continuous hours.

4. Closed building conditions are when all ___*windows and exterior doors*___ are kept closed, except for brief ___*entry and exits*___.

5. There are two conditions when you should not test for radon. These are:

   When using short-term tests and there is unusual weather such as heavy rains, heavy snows, or high winds.

   During the renovation of the school building or school's HVAC system during any type of test.

Correct Answers for Activity 3-2

Answer the following questions:

1. You have scheduled a 4-day initial test during the first week of November. The weather forecast for that week is: heavy rains for Sunday, high winds with possible showers on Monday, sunny and clear for the remainder of the week except for a slight chance of late evening showers on Friday. When would you start and end the test? Explain your decisions.

   Postpone the test until the following week or until the weather conditions are more appropriate because the "window of opportunity" for favorable testing conditions is too limited.

2. EPA guidance recommends initial testing during the colder months of the school year (October to March). Keeping in mind that you may have to conduct follow-up tests, select the time period you will begin your initial testing. Consider the length of your initial test when making your decision.

   Initial testing can begin in late October when buildings begin to be closed up because of cooler weather. This gives you ample time to complete your initial test during the colder months of the year. Also, it enables you to conduct short-term follow-up testing—if necessary—under similar conditions as initial testing.

3. You planned to conduct a 2-week initial test during the latter half of October. The weather forecast indicates that the weather will be unseasonably warm during this time of the month. Would you postpone testing given this information? Explain why you would/or would not postpone testing.

   Yes, testing should be postponed until the weather turns cooler because in unseasonably warm weather school occupants will be inclined to open windows.

UNIT 4

What Rooms to Test

Unit Overview

This unit describes which rooms in the school should be tested, and where to place a measurement device in a schoolroom. The unit is divided into three sections: determining what rooms to test, placing detectors in a room, and a unit summary.

Participant Objectives

After the completion of this unit, participants will be able to:

- Identify those rooms in typical school designs (and their own school, if appropriate) that are recommended for testing according to the EPA guidelines.
- Follow a detector placement checklist to identify locations within rooms that are appropriate and inappropriate for detector placement.

Determining What Rooms to Test

EPA recommends that radon measurements be conducted in *all frequently-occupied rooms that are in contact with the ground.*

These are usually classrooms, offices, gymnasiums, auditoriums, and cafeterias. Areas such as storage rooms, stairwells, rest rooms, utility closets, kitchens, elevator shafts or hallways *need not* be tested. These areas may be important for diagnostic testing if elevated levels of radon are found. In addition, rooms that are not now frequently-occupied but *will be in the future* should be tested.

When placing detectors, room size is also a factor. For larger school rooms, one detector per 2000 square feet of floor area is

For additional information on this subject, see Section II.C of the EPA guidance document, "Radon Measurement in Schools—Revised Edition" (pages 9 and 10).

recommended. This would not be an issue in a typical classroom that is usually less than 1000 square feet, however, the size of auditoriums, cafeterias, and other large spaces must be calculated to determine the appropriate number of measurement devices.

Before beginning the testing, it is important to develop a floor plan clearly showing which rooms are to be tested.

The following are frequently occupied rooms that need to be tested:

- basement classrooms and offices
- rooms above enclosed crawl spaces
- rooms on the ground floor over a slab
- rooms built into the side of a hill with walls in contact with the earth

Three common foundation types that may exist under all or parts of a school (**slabs-on-grade, crawl spaces**, and **basements**) are shown and described in the Figures 4-1, 4-2, and 4-3.

Many schools have different foundation types in different parts of the school; for example, part of a school was built with a basement foundation and other areas were built with a slab-on-grade foundation. In addition, interior areas of the school may be separated by structural walls or may have an open floor plan. Because of these differences between areas within a school, it is important for the school official planning the testing program to evaluate each room or area to determine whether it is an appropriate to testing location.

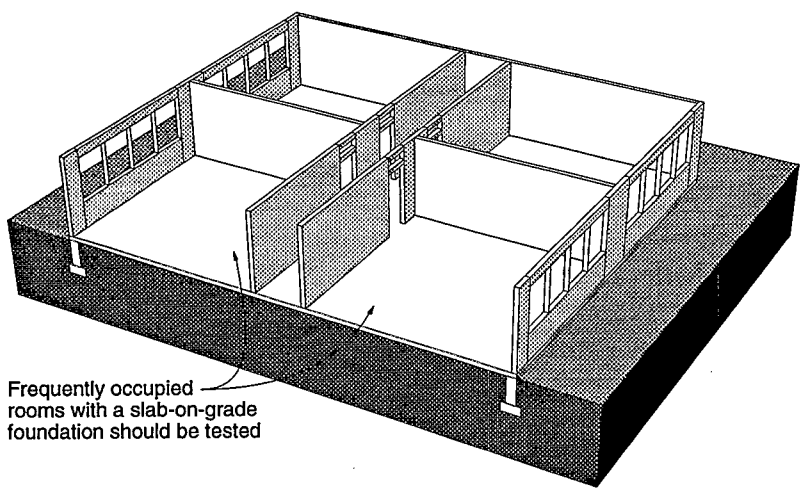


Figure 4-1: Slab-on-grade— A room on a slab-on-grade foundation should be tested if it is frequently-occupied.

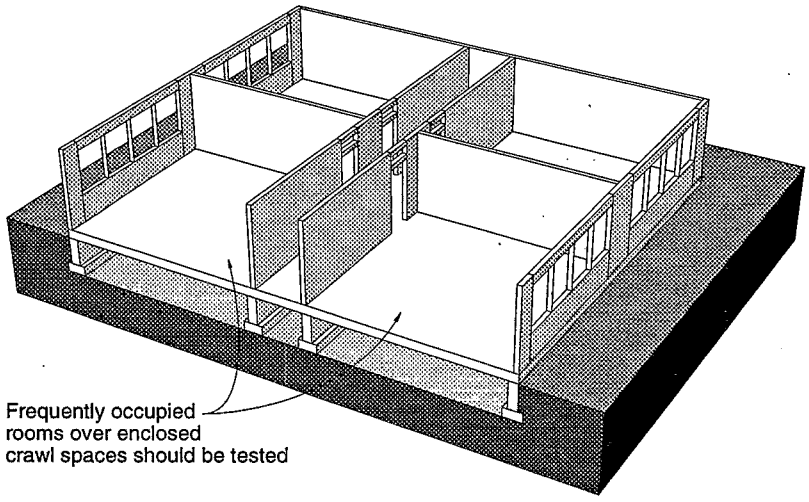


Figure 4-2: Crawl space—A frequently-occupied room on a crawl space foundation should be tested if the room is directly above the crawl space and if the crawl space is enclosed. If the crawl space is completely open on at least one side to the outdoor air—without any wall, door, or barrier—consider this room or area to be essentially above ground on stilts. Therefore, it need not be tested.

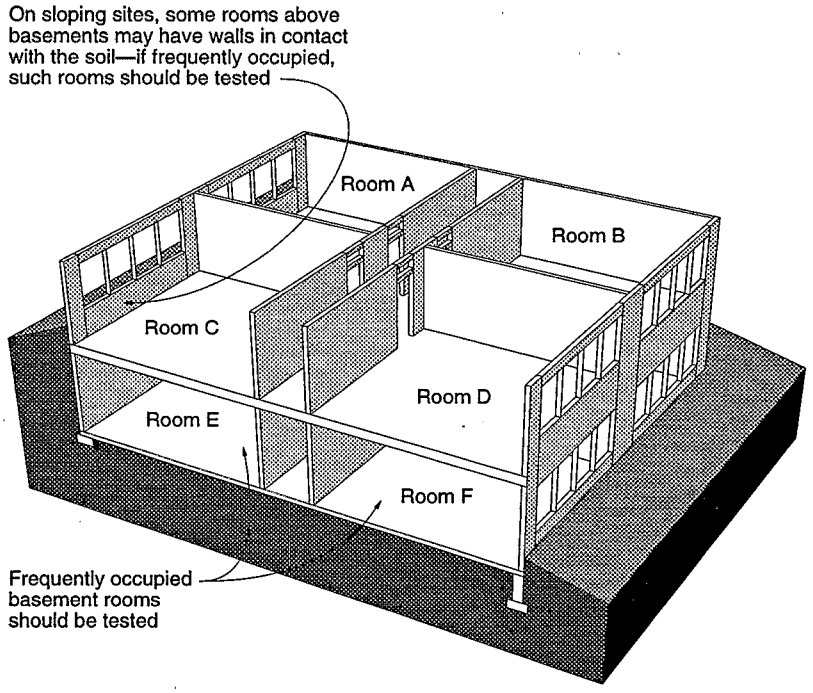


Figure 4-3: Basement—Radon measurements should be conducted in all frequently-occupied basement rooms. Some schools are built on a slope so that there are rooms in the school that are at a higher grade than the basement but have walls with some contact with the ground. Other rooms may be directly above basement rooms and still have a wall with some ground contact. All rooms above a basement level that have at least one wall with substantial ground contact should be tested for radon.

Research indicates that radon levels on upper floors are not likely to exceed the level found in ground contact rooms. Testing rooms on the ground contact floor is sufficient to determine if there is a problem in a school. Also, if remedial action reduces radon levels on the ground floor, radon levels in the upper floors will also be reduced.

Activity 4-1

1. The six rooms shown in Figure 4-3 are identified by a letter. Indicate which rooms you will test.

2. List the types of rooms that will require testing in your own facility.

3. List the types of rooms that you may not wish to test in your own facility.

4. Indicate the foundation types used in your own facility (slab-on-grade, crawl space, basement, or a combination of these).

Placing Detectors in a Room

The detectors should be placed in an area of the room where they will measure a representative sample of indoor air for that room. A checklist for device placement is shown in the box below.

Locations on an inside wall and away from vents are usually a good choice. Some detectors may be hung from tacks on walls/bulletin boards or from ceilings while other types may be placed on the upper shelves of a bookcase.

Since the detectors will be opened simultaneously or as close in time as is reasonable and possible, *each room should be checked ahead of time for a good location, and the teacher or a frequent user of that room should be aware of the detector. In addition, the materials necessary for placement of the detectors should be in hand and the school official placing the detectors should be familiar with and have practiced the deployment and retrieval procedures.*

For additional information on this subject, see Section II.C of "Radon Measurement in Schools—Revised Edition" (page 10)—the EPA guidance document.

You may need strong adhesive tape, scissors, thumb tacks, string etc. to properly place a detector

Detector Placement Checklist

- ❑ Place detectors *away from drafts* caused by heating, ventilating vents, air conditioning vents, fans, doors, and windows. *At least three feet from doors and windows* and preferably farther will help ensure that drafts do not interfere with the measurement.
- ❑ Place detectors where they will *not be touched or covered.* Some types of devices will not yield a correct result if they are dropped, and many will not operate at all if there is no open air around them.
- ❑ Place detectors away from direct sunlight.
- ❑ Place detectors away from sources of humidity (avoid placing near sinks, aquariums, or showers).
- ❑ At least one detector should be placed for every 2000 square feet of floor area if there are large areas to be tested.
- ❑ Place detectors at least 20 inches from the floor and 4 inches from other objects.
- ❑ Place detectors away from outside/exterior walls of the building.

Activated charcoal devices will absorb the moisture in humid air. The presence of water on the activated charcoal device will affect the accuracy of its measurement so avoid placing them near sources of moisture.

Activity 4-2

A typical two-level school is shown in cross section and floor plan drawings on this and the facing page. A **cross section** shows a side view of a building that has been cut through to reveal what is inside. A **floor plan** shows a top view of a building with the roof taken off. If it is a multistory building, the plan view looks at a particular floor with all the floors above removed. *The three cross sections on this page (Figures 4-4, 4-5, and 4-6) correspond to the section lines on the two floor plans (Figures 4-7 and 4-8).* To assist you with determining the appropriate number of detectors per school room, dimensions are given so that the floor area of a particular room can be calculated if necessary.

Place detectors about every 2,000 square feet for large spaces.

After examining the floor plans and cross sections, indicate on the plans which rooms require measurement devices and how many detectors are required in each room.

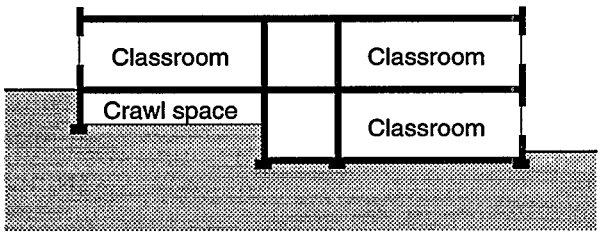


Figure 4-4: Cross section A-A′ of part of a typical school.

See Figure 4-7 and 4-8 for the location of these cross sections on the building floor plan.

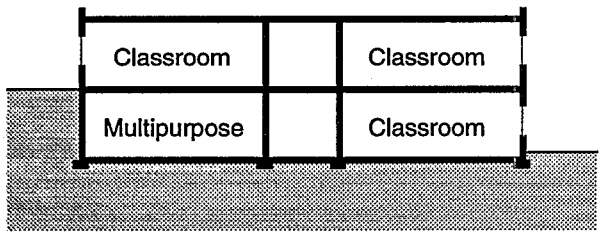


Figure 4-5: Cross section B-B′ of a typical school.

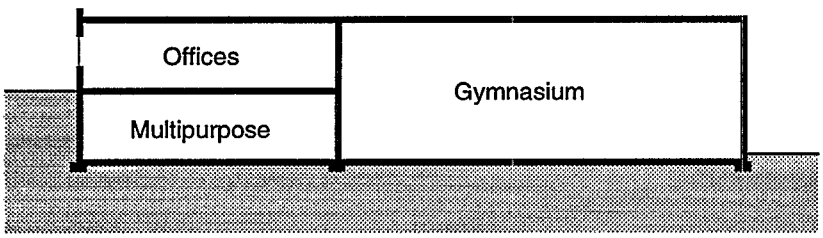


Figure 4-6: Cross section C-C′ of a typical school.

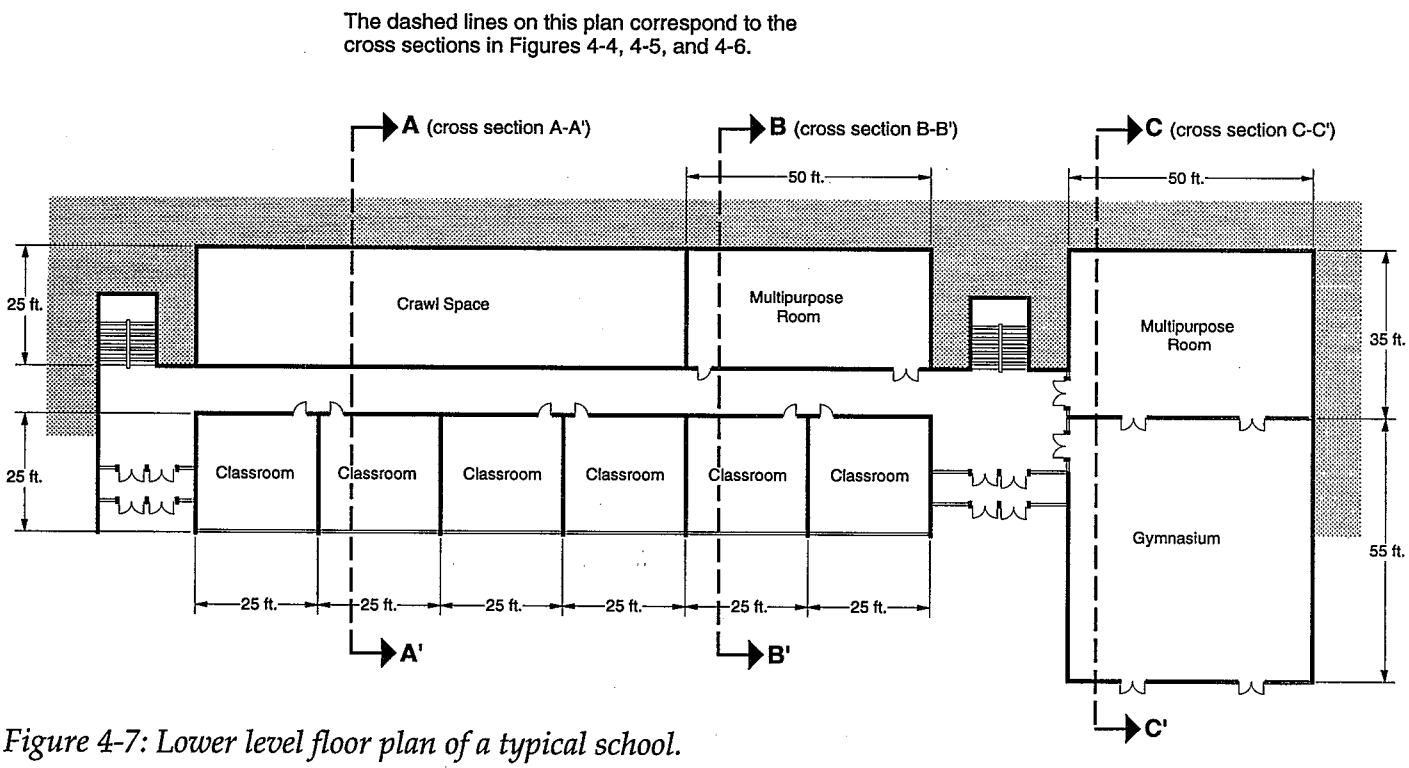


Figure 4-7: Lower level floor plan of a typical school.

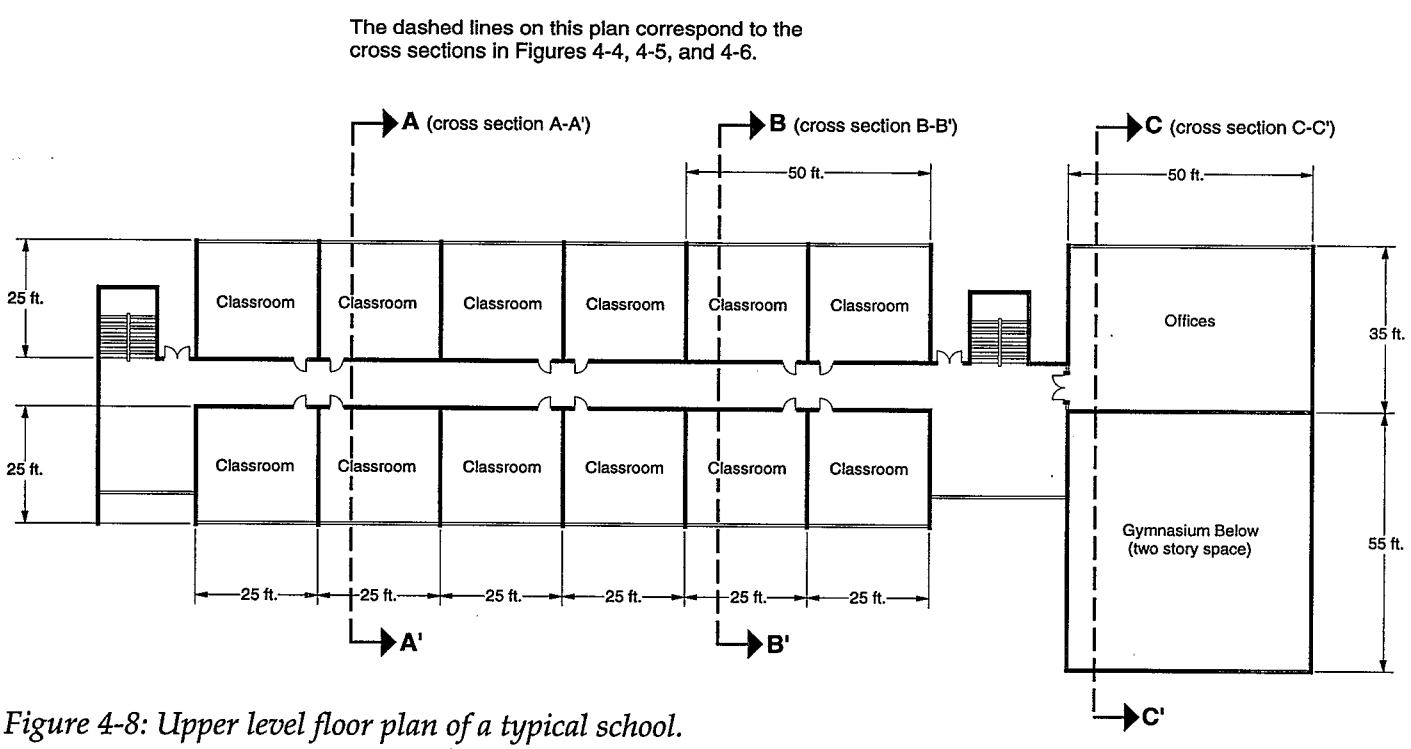


Figure 4-8: Upper level floor plan of a typical school.

Activity 4-3

A plan of a typical classroom is shown here. Indicate on the plan where measurement devices could be placed in the room. Indicate the proper height at which each measurement device is placed as well.

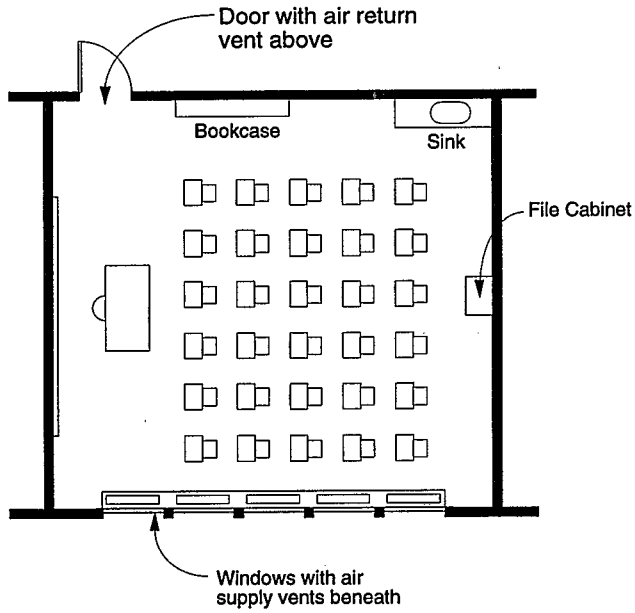


Figure 4-9: Floor plan of a typical classroom.

Unit Summary—What Rooms to Test

This unit describes the EPA guidance for choosing the best locations for detectors, both in terms of the rooms and areas of the school that should be tested and where to place devices within a room.

- The EPA recommends that tests be made in those rooms and areas that are frequently-occupied and have a floor or a wall touching the ground or above an enclosed crawl space, such as:

  —basement classrooms and offices.

  —rooms above enclosed crawl spaces.

  —rooms on the ground floor over a slab.

  —rooms built into the side of a hill with earth contact walls.

- If there are large areas to be tested, detectors should be placed at least every 2000 square feet.
- Within the rooms to be tested, detectors should be placed away from drafts, sunlight, or humidity.
- Detectors should be placed at least three feet from doors and windows, and preferably farther.
- Detectors should be placed at least 20 inches from the floor and 4 inches from other objects.
- Detectors should be placed away from outside (exterior) walls of the building.
- Detectors should not be touched or moved during the measurement.

Correct Answers for Activity 4-1

1. The six rooms shown in Figure 4-3 are identified by letter. Indicate which rooms you will test.

   You should test rooms A, C, E and F. Rooms A and C have some ground contact on the lower part of the exterior wall. Rooms E and F are basement rooms.

2. List the types of rooms that will require testing in your facility.

   Typical answers:

   Classrooms

   Offices

   Gymnasiums and auditoriums

   Cafeterias

3. List the types of rooms that you may not wish to test in your facility.

   Typical answers:

   Storage rooms and utility closets

   Rest rooms

   Corridors and stairwells

   Elevator shafts

   Locker rooms/showers

4. Indicate the foundation types used in your facility (slab-on-grade, crawl space, basement, or a combination of these).

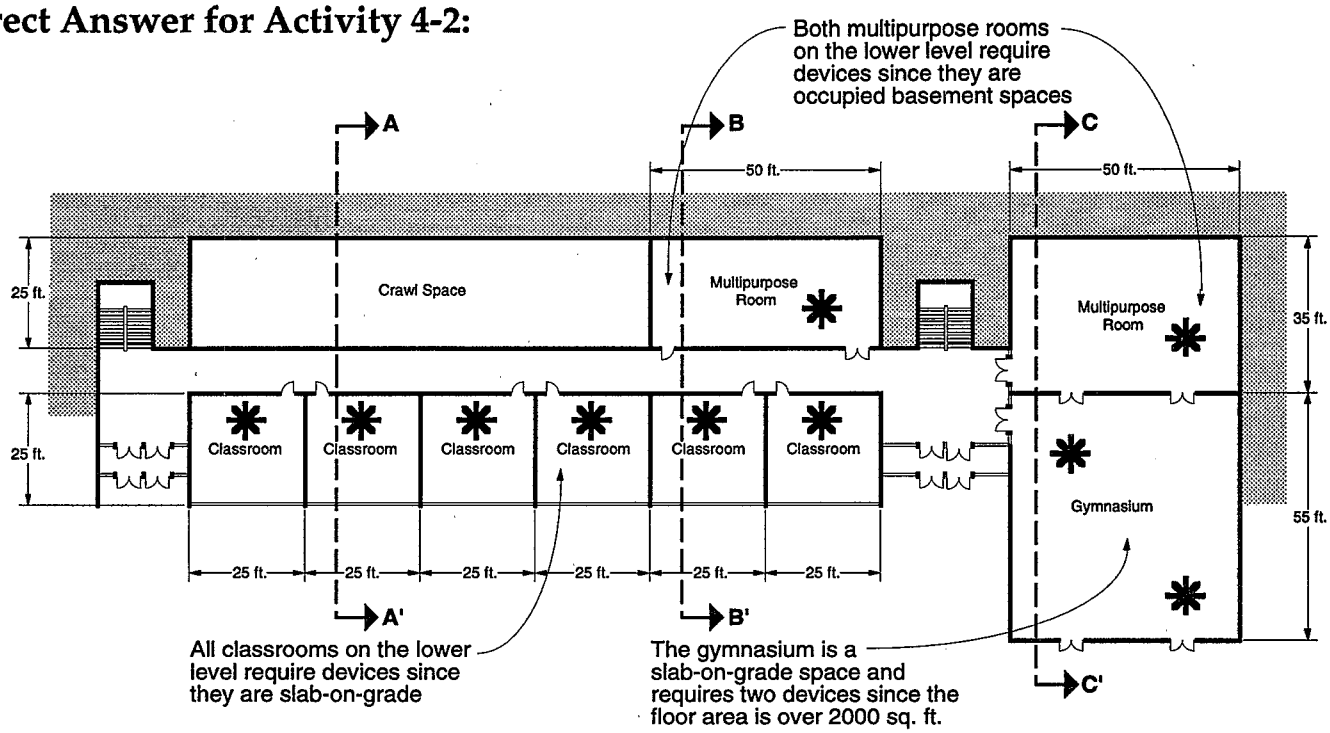
   Typical answers:

   Slab-on grade

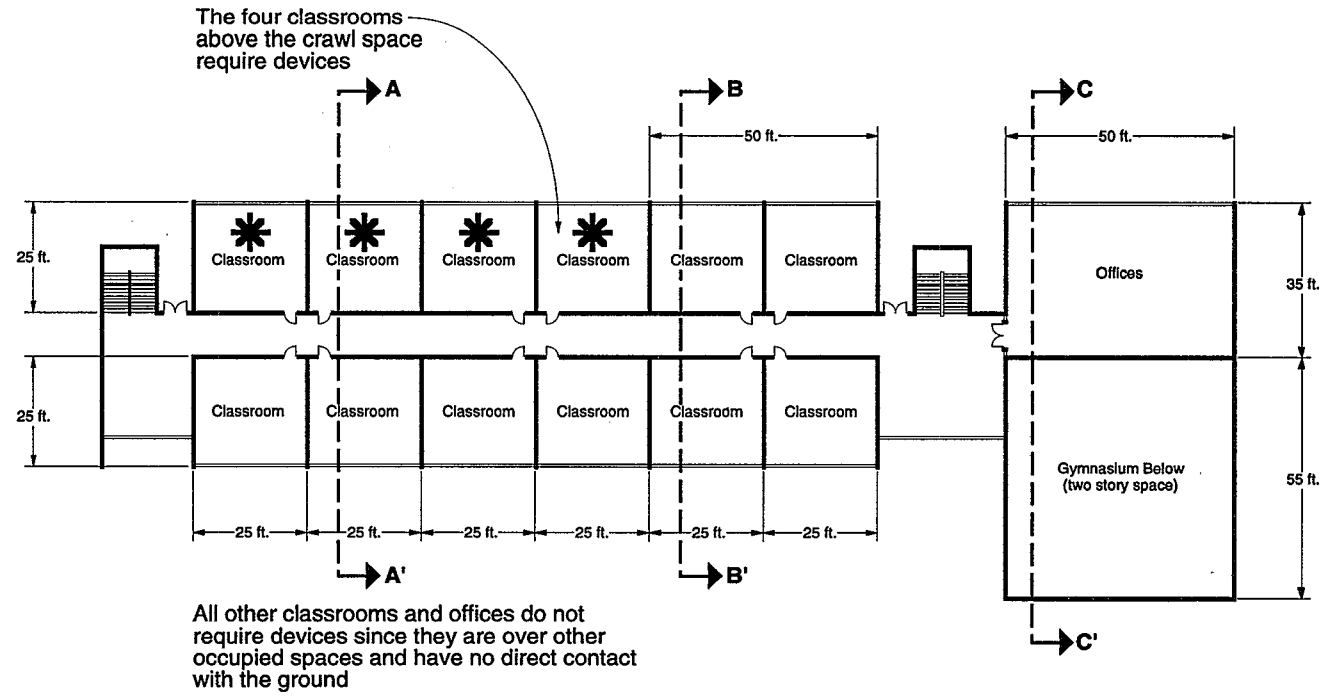
   Crawl spaces

   Basement

Correct Answer for Activity 4-2:



Correct answer for Figure 4-7: Lower level plan of a typical school showing placement of detectors.



Correct answer for Figure 4-8: Upper level plan of a typical school showing placement of detectors.

Correct Answer for Activity 4-3:

In addition to indicating where to place the detectors on the plan, the participant should note that the detector must be placed at least 20 inches above the floor.

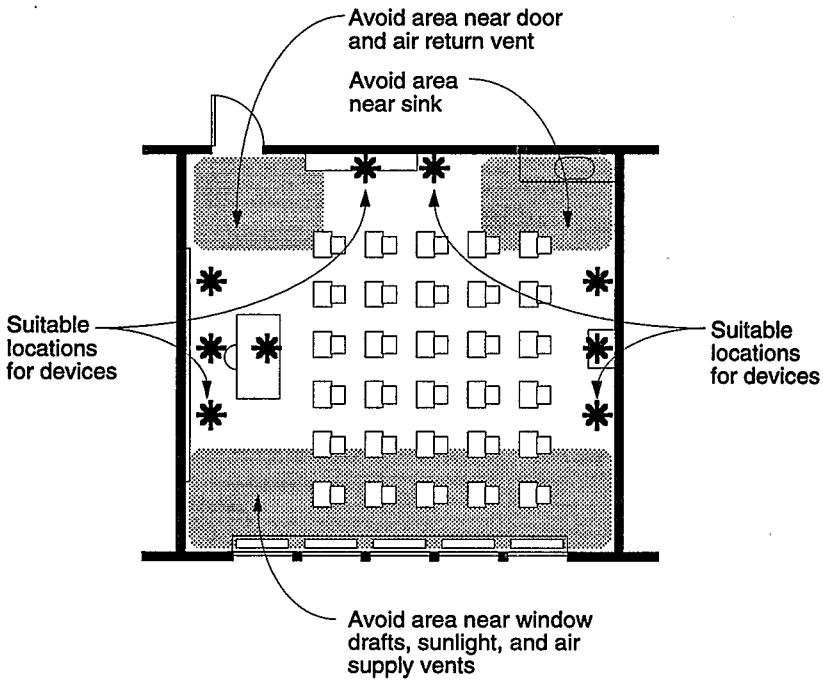


Figure 4-9: Plan of a typical classroom showing several suitable locations for placement of detectors. Only one detector is required for this room.

UNIT 5

Quality Assurance Measurements

Unit Overview

This unit reviews the EPA guidance for quality assurance as a key component of a school radon testing program. Part of the quality assurance activities include the performance of quality assurance measurements which consist of using duplicate and blank measurement devices.

For more information on Quality Assurance measurements, see Section F (page 14) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

Participant Objectives

Upon completion of this unit, students will be able to:

- Define quality assurance
- Cite the purpose of making duplicate measurements
- Cite the purpose of making blank measurements
- Describe how to make duplicate and blank measurements as part of a school radon testing program
- Learn how to keep a written record of test locations and detectors that were used in a testing program

Use detectors from a RMP-listed or state certified laboratory—contact your State Radon Office for more information.

Definitions

Quality assurance (QA) is an umbrella term that includes all the activities done to make sure that the results from a testing program are reliable (i.e., accurate and precise).

QA is a key component of your testing program. If high radon levels are found, the decision to mitigate rests upon the quality of the radon measurements. It is necessary to document your quality assurance activities in case the results of the program are questioned. This unit describes the basic elements of a quality assurance program for school officials. The

manufacturer of your measurement device will also have their own QA program. *The QA program conducted by school officials is necessary, even if they are similar to those conducted by the service providing the measurement device and their analysis.* The following should be the elements of a QA program for school testing:

- **Quality assurance measurements** include duplicate measurements to evaluate precision and blank measurements help to evaluate accuracy.
- **Record keeping** includes careful use of the floor plan, device placement log, device labels, and any other record keeping associated with the testing program. Each person responsible for any record keeping activity should be trained ahead of time so that they understand how and where to record information. A notebook dedicated to the measurement program can be used for recording significant events, corrective actions, dates, and times.
- **Chain-of-custody** includes designating areas for detector storage, persons authorized to handle devices, and procedures for tracking detectors when they are received from manufacturer, placed, retrieved, or stored in another area or building.
- **Corrective actions** are taken when the results of the quality assurance measurements are not within the guidelines. Corrective actions should be authorized by the manager of a testing program. The testing manager should describe the corrective action in a notebook and this description should be dated, initialed, and filed with other records of the testing program.

Appendix A on page A-1 of this document describes the quality assurance plans for a device manufacturer.

Quality Assurance (QA) Measurements

QA measurements are part of quality assurance and are made to check the operation of your detectors and measurement program. QA measurements:

- include duplicates and blanks.
- are part of both initial and follow-up testing.

Duplicate Measurements

The purpose of duplicate measurements is to assess how well two side-by-side measurements with the same type of device agree with each other (**precision**).

Duplicate measurements have the following characteristics:

- They are made with paired detectors placed side-by-side.
- Each detector measures the same indoor air environment and, therefore, they should give similar test results.
- They represent 10% of all the detectors deployed or 50 detectors whichever is less.

The pairs should be kept together during and after the measurement (e.g., pairs stored and shipped back in the same box).

The test result for a room where a duplicate pair was placed should be the average of the duplicate pair.

On page 37 of Appendix E of EPA's guidance document, there are 11 steps that describe how to determine if the differences between your duplicates are acceptable.

In more technical documents, quality assurance measurements are referred to as quality control measurements. For a step-by-step procedure for evaluating the results of blank and duplicate measurements, see Appendix E (pages 37-39) of the EPA guidance document "Radon Measurement in Schools—Revised Edition."

Blank Measurements

Blank measurements are made to determine:

- whether any radon or other type of background contamination leaked into the detectors during shipment or storage.
- whether there are problems with the calibration of the laboratory equipment used to analyze your exposed detectors.
- whether errors were made in recording and reporting the laboratory results.
- if any other occurrence (dropping a box of detectors, for example) changed the way the detectors respond.

Blank measurements should yield results that are close to zero.

Blank measurements:

- are not exposed.
- should be stored with the other detectors before and after deployment.
- should be included with each shipment to the laboratory.

For more information on duplicate and blank measurements, see Section F (page 14) of the EPA guidance document.

- should be 5 percent of all the detectors deployed or 25 whichever is less.

All the results of the blanks should be less than 1 pCi/L.

QA Measurements During Follow-up Testing

Blanks and duplicates should be part of *both* initial and follow-up testing. Even if only a few follow-up measurements are needed, a minimum of one pair of duplicates and one blank should be part of follow-up testing.

Activity 5-1

Fill in the blanks.

1. Quality assurance includes_____ _____.

2. Quality assurance measurements are made to_____ _____.

3. The purpose of making duplicate measurements is to assess _____, or how well _____ _____.

4. Duplicates should be placed in _____ percent of all measurement locations, or 50 total pairs, whichever is less.

5. A purpose of blank measurements is to assess _____, which can affect _____.

6. Blank measurements should be made in _____ percent of the total number of devices placed, or 25, whichever is less.

Activity 5-2

1. Mark which rooms on the floor plan in Figure 5-1 will have duplicate measurements. The classrooms marked with stars on this floor plan are considered frequently occupied rooms that are in contact with the ground and, therefore, should be tested. *(Suggestion: Make a duplicate measurement for every ten measurement locations—i.e., 10% of all testing locations. If you have extra rooms after assigning duplicate detectors at a rate of one per 10 measurement locations, add one additional duplicate detector.)*

2. For Figure 5-1, randomly assign (but do not place) blank devices to rooms that are frequently occupied and in contact with the ground (rooms with stars) that do not contain duplicate measurements. **Remember that you do not use these devices to test any room. However, you do remove them from their packaging and then immediately reseal them to give them the appearance they have been used.** How many blank devices are required for the school in Figure 5-1? *(Suggestion: Assign a blank measurement for every twenty measurement locations. If you have extra rooms remaining after assigning blank detectors at a rate of one per 20 rooms, add one additional blank detector.)*

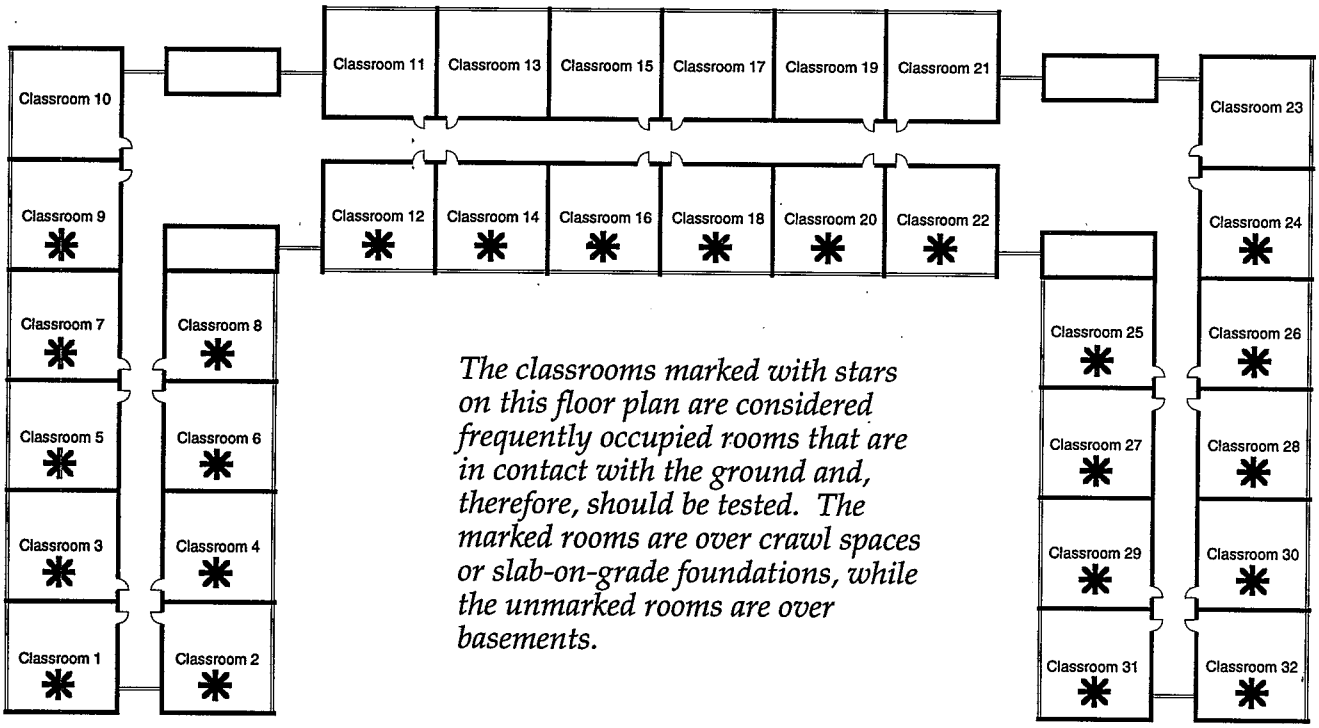


Figure 5-1: Floor plan of school.

Record Keeping

Blanks and duplicates should:

- be noted by you on the Device Placement Log and Floor Plan by serial number.
- *not* be labelled as blanks or duplicates on the detectors.

The analysis laboratory will therefore handle them just as they handle the other detectors, and you will get an assessment of accuracy and precision. This will require using fictitious start dates and times for the blanks and duplicates.

A device placement log is provided on page 45 of the EPA guidance document "Radon Measurement in Schools - Revised Edition." Make copies of this log sheet when preparing to test your school.

Activity 5-3

1. You have labelled the location of Blanks (B) and Duplicates (D) on the floor plan in Activity 5-2. "D" indicates a duplicate. "B" indicates a blank. All rooms containing a star on this floor plan will be tested. Prepare a *Device Placement Log* (blank form on the next page) that records each testing location, duplicate measurement, and blank measurement.

   An example of a **completed** Device Placement Log is shown in Figure 5-3. For another example, turn to the last two pages of EPA's guidance document and study how the duplicates and blanks on the sample floor plan were recorded on the first two columns of the sample device placement log.

2. What steps are necessary to prepare your Device Placement Log for the lab that will analyze the detectors recorded on this log. (For guidance on what to do, see steps 22-25 on page 44 of EPA's guidance document. These steps are part of the Procedural Checklist for Radon Testing on page 40 of the guidance document.)

Figure 5-2: Device Placement Log

SCHOOL:_____

Room #/Name	Location	Serial #	Start Date	Start Time	Stop Date	Stop Time	Comments	Result

NAME:_____

Figure 5-3: Example of Completed Device Placement Log SCHOOL: Example

Room #/Name	Location	Serial #	Start Date	Start Time	Stop Date	Stop Time	Comments	Result
Classroom 100	teacher's desk	SL456	11/8/93	6:22 am	11/12/93	6:15 am		1.7
Classroom 102	teacher's desk	SL967	11/8/93	6:23 am	11/12/93	6:17 am		3.2
Classroom 103	top of lockers	SL228	11/8/93	6:25 am	11/12/93	6:21 am		0.7
Classroom 104	top of lockers	SL725	11/8/93	6:29 am	11/12/93	6:25 am		0.5
duplicate		SL178	11/8/93	6:32 am	11/12/93	6:28 am		1.0
Classroom 105	teacher's desk	SL936	11/8/93	6:35 am	11/12/93	6:32 am		5.3
Classroom 106	teacher's desk	SL478	11/8/93	6:38 am	11/12/93	6:40 am		3.4
Classroom 107	top of lockers	SL934	11/8/93	6:42 am	11/12/93	6:45 am		1.3
Classroom 108	top of lockers	SL225	11/8/93	6:53 am	11/12/93	6:48 am		1.5
Classroom 109	top of lockers	SL632	11/8/93	6:55 am	11/12/93	6:52 am		3.9
Classroom 112	top of filing cabinet	SL716	11/8/93	7:01 am	11/12/93	6:58 am		5.7
duplicate		SL833	11/8/93	7:05 am	11/12/93	7:05 am		6.0
Classroom 113	top of filing cabinet	SL221	11/8/93	7:10 am	11/12/93	7:07 am		2.5
Classroom 116	on fire ext. case	SL037	11/8/93	7:12 am	11/12/93	7:10 am		4.2
Classroom 118	south wall shelves	SL309	11/8/93	7:15 am	11/12/93	7:13 am		1.4
Classroom 201	on fire ext. case	SL102	11/8/93	7:19 am	11/12/93	7:17 am	label was retaped on	7.5
Classroom 202	on fire ext. case	SL993	11/8/93	7:21 am	11/12/93	7:21 am		2.3
Classroom 204	top bookshelf	SL687	11/8/93	7:25 am	11/12/93	7:24 am		0.8
Classroom 205	top bookshelf	SL063	11/8/93	7:30 am	11/12/93	7:28 am		2.1
duplicate		SL005	11/8/93	7:32 am	11/12/93	7:33 am		1.5
Classroom 206	bookshelf	SL912	11/8/93	7:35 am	11/12/93	7:36 am		5.6
Classroom 207	teacher's desk	SL687	11/8/93	7:40 am	11/12/93	7:41 am		4.5
Classroom 208	filing cabinet	SL445	11/8/93	7:43 am	11/12/93	7:45 am		1.7
blank		SL781	11/8/93	7:47 am	11/12/93	7:48 am		0.2
Classroom 209	bookshelf	SL567	11/8/93	7:50 am	11/12/93	7:53 am		1.2
Classroom 301	teacher's desk	SL402	11/8/93	7:55 am	11/12/93	7:59 am		2.5
Classroom 302	teacher's desk	SL780	11/8/93	7:59 am	11/12/93	8:03 am		0.9
Classroom 303	teacher's desk	SL693	11/8/93	8:05 am	11/12/93	8:10 am		3.1
Office	teacher's desk	SL694	11/8/93	8:09 am	11/12/93	8:14 am		5.1
duplicate		SL005	11/8/93	8:15 am	11/12/93	8:19 am		4.3

NAME:_____

Corrective Action Based on the Results of QA Measurements

If you have questions while interpreting your QA results, contact your State Radon Office listed in the EPA guidance document on page 28.

If after following the procedure on page 37 of the EPA guidance document, you determine that your:

1. **Duplicate measurements are not precise**—in other words, the average of the relative percent differences (ARPD) is greater than 25% *and/or*
2. **Blank measurements are not accurate**—in other words, one or more blanks had a value greater than 1.0 pCi/L.

   ACTION: If the quality of the measurements is questionable, contact the analyzing laboratory and request assistance in determining if there is a problem and if any retesting is necessary.

Figure 5-4: Duplicate Log SCHOOL:_____

D_1	D_2	M	M ≥ 4 ?	RPD

Activity 5-4

1. Transfer the results of the duplicates on the completed *Device Placement Log* (Figure 5-3) onto the *Duplicate Log* (Figure 5-4) following steps 1 and 2 on page 37 of EPA's guidance document "Radon Measurement in Schools - Revised Edition."

2. Using the completed Duplicate Log, evaluate the precision of these duplicate measurements following steps 3 through 11 on page 37 and 38 of EPA's guidance document. Based upon your evaluation, do your results show adequate precision? *For an example, see step 10 on page 38 of EPA's guidance document Radon Measurement in Schools - Revised Edition.*

Unit Summary - Quality Assurance Measurements

Quality assurance is defined as all those activities that are done to verify that radon test results are reliable. This includes:

- careful record keeping.
- chain-of-custody.
- quality assurance measurements.
- corrective actions.

Quality assurance measurements consist of:

- duplicates, made to assess precision, or how well two side-by-side measurements agree.
- blanks, used to assess accuracy.

If the results of duplicates or blanks are not within the limits presented in Appendix E of the EPA schools guidance, the testing manager should contact the analysis laboratory for assistance. It may be necessary to take corrective action. Corrective action may consist of:

- retesting if the average relative percent difference (ARPD) is greater than 25%.
- retesting if one or more blanks are greater than 1.0 pCi/L.

Correct Answers for Activity 5-1

Fill in the blanks.

1. Quality assurance includes ___*all the activities done to make sure the results from a radon testing program are reliable.*___

2. Quality assurance measurements are made to ___*check the operation of your detectors and measurement program.*___

3. The purpose of making duplicate measurements is to assess ___*precision*___, or how well ___*two side-by-side measurements agree*___.

4. Duplicates should be placed in ___*10*___ percent of all measurement locations, or 50 total pairs, whichever is less.

5. A purpose of blank measurements is to assess ___*background radiation*___, which can affect ___*accuracy*___.

6. Blank measurements should be made in ___*5*___ percent of the total number of devices placed, or 25, whichever is less.

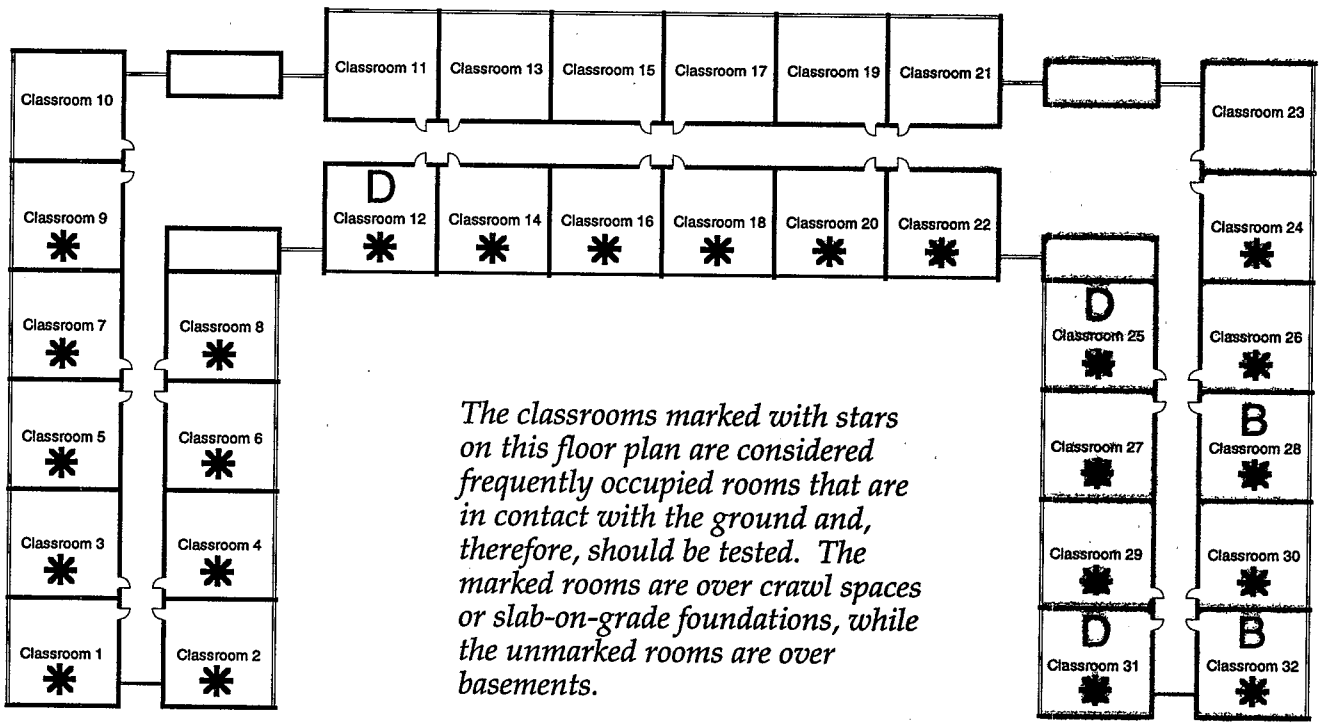
Correct Answers for Activity 5-2

1. Mark which rooms on the floor plan in Figure 5-1 will have duplicate measurements. The classrooms marked with stars on this floor plan are considered frequently occupied rooms that are in contact with the ground and, therefore, should be tested. *(Suggestion: Make a duplicate measurement for every ten measurement locations—i.e., 10% of all testing locations. If you have extra rooms after assigning duplicate detectors at a rate of one per 10 measurement locations, add one additional duplicate detector.)*

   Since there are 24 measurement locations, there should be three rooms that will receive duplicate devices (i.e. one for every 10 measurement locations and one for the four extra rooms). These are marked with a "D" on the floor plan on the next page.

2. For Figure 5-1, randomly assign (but do not place) blank devices to rooms that are frequently occupied and in contact with the ground (rooms with stars) that do not contain duplicate measurements. Remember that you do not use these devices to test any room. However, you do remove them from their packaging and then immediately reseal them to give them the appearance they have been used. How many blank devices are required for the school in Figure 5-1? *(Suggestion: Assign a blank measurement for every twenty measurement locations. If you have extra rooms remaining after assigning blank detectors at a rate of one per 20 rooms, add one additional blank detector.)*

Since there are 24 measurement locations, there should be two blank devices (i.e. one blank for every 20 testing locations plus one for the four extra rooms). ***Although blank devices are not placed in a testing location, they show up on the floor plan. This helps to ensure that they will be incorporated into the device placement log.***



Correct answers for Activity 5-2: Duplicate device placement for floor plan of school.

Correct Answers for Activity 5-3

1. You have labelled the location of Blanks (B) and Duplicates (D) on the floor plan in Activity 5-2. "D" indicates a duplicate. "B" indicates a blank. All rooms containing a star on this floor plan will be tested. Prepare a *Device Placement Log* (blank form on the next page) that records each testing location, duplicate measurement, and blank measurement.

   An example of a **completed** Device Placement Log is shown in Figure 5-3. For another example, turn to the last two pages of EPA's guidance document and study how the duplicates and blanks on the sample floor plan were recorded on the first two columns of the sample device placement log.

   See completed Device Placement Log on next page. Note, you may have selected different rooms for your duplicates and blanks; however, the labelling of duplicates and blanks should be similar in format to the workbook's example.

   These log sheets can serve as a guide while placing and retrieving detectors.

2. What steps are necessary to prepare your Device Placement Log for the lab that will analyze the detectors recorded on this log. (For guidance on what to do, see steps 22-25 on page 44 of EPA's guidance document. These steps are part of the Procedural Checklist for Radon Testing on Page 40 of the guidance document.)

   Make a copy of the Device Placement Log with the Room#/ name and Location columns covered. Include this special copy with the detectors mailed to the laboratory for analysis. This special copy of your log sheet keeps the identities of the duplicates and blanks masked from the lab. Since the QA measurements are—in part—a check on the lab analyzing your results, the lab cannot identify which detectors are blanks (i.e., which detectors should have test results close to or equal to zero) and which detectors are duplicates (i.e., which detectors should have very similar test results).

Correct answers for Activity 5-3: Device Placement Log SCHOOL: Figure 5-1

Room #/Name	Location	Serial #	Start Date	Start Time		Stop Time	Comments	Result
Classroom 1	teacher's desk							
Classroom 2	teacher's desk							
Classroom 3	top of lockers							
Classroom 4	top of lockers							
Classroom 5	teacher's desk							
Classroom 6	teacher's desk							
Classroom 7	top of lockers							
Classroom 8	top of lockers							
Classroom 9	top of lockers							
Classroom 12	top of filing cabinet							
D	duplicate							
Classroom 13	top of filing cabinet							
Classroom 16	on fire ext. case							
Classroom 18	south wall shelves							
Classroom 20	on fire ext. case							
Classroom 22	on fire ext. case							
Classroom 24	top bookshelf							
Classroom 25	top bookshelf							
D	duplicate							
Classroom 26	bookshelf							
Classroom 27	teacher's desk							
Classroom 28	filing cabinet							
B	blank							
Classroom 29	bookshelf							
Classroom 30	teacher's desk							
Classroom 31	teacher's desk							
Classroom 32	teacher's desk							
B	blank							

Note: This partially completed device placement log is based on the floor plan on page 61. The order in which you listed classrooms and selected locations for duplicates and blanks may differ. However, the manner in which duplicates and blanks were listed should be similar. For example, classroom 12 identifies the first duplicate and the entry below it identifies the second duplicate. Although blanks are not actually placed in rooms marked "B", they are listed in these rooms for record keeping purposes.

NAME:_____

Correct Answers for Activity 5-4

1. Transfer the results of the duplicates on the completed *Device Placement Log* (Figure 5-3) onto the *Duplicate Log* (see the adjacent blank form). Follow steps 1 and 2 on page 37 of EPA's guidance document.

   See completed Duplicate Log below.

2. Using the completed Duplicate Log , evaluate the precision of these duplicate measurements following steps 3 through 11 on page 37 and 38 of EPA's guidance document. Based upon your evaluation, do your results show adequate precision? *For an example, see step 10 on page 38 of EPA's guidance document Radon Measurement in Schools - Revised Edition.*

   Based upon the duplicate analysis below, the average relative percent difference is 11.1%. This indicates that the duplicates show adequate precision.

Correct answers for Figure 5-4: Duplicate Log

SCHOOL:_____.

D_1	D_2	M	M ≥ 4 ?	RPD
0.5	1.0	.75		
5.7	6.0	5.9	X	5.1 %
2.1	1.5	1.8		
5.1	4.3	4.7	X	17.0 %
			N = 2	TRPD = 22.1 %

ARPD = TRPD / N = 22.1 / 2 = 11.1 %

UNIT 6

Implementation of the School Radon Testing Program

Unit Overview

This unit presents an overview of a radon testing program for a school. The Procedural Checklist in Appendix F (page 40) of the EPA guidance document is applied to a case-study school and/or the participant's own school. This checklist is a blueprint for a testing program, from the initial planning phases through deployment and retrieval. Highlights of this procedural checklist are provided at the end of this unit. Participants may record notes and pertinent information from their own school or the school in the case-study on the abbreviated procedural checklist in this unit.

Participant Objectives

After the completion of this unit, participants will be able to demonstrate their familiarity with and understanding of the guidance for radon testing in schools by doing the following:

- planning a testing program,
- documenting the deployment of detectors on a floor plan,
- employing proper record-keeping on a Device Placement Log,
- documenting the placement and retrieval of the detectors, and
- preparing the Device Placement Log Sheet for the laboratory analysis.

Case Study of an Elementary School

This is a one-story, 15,000-square-foot elementary school with eight classrooms. This elementary school was built in 1959, with brick veneer and masonry and *slab-on-grade* construction. The floor plan is shown in Figure 6-1. This school was measured in 1990 (using EPA's interim guidance). This floor plan can be used as an example in order to complete the checklist on the following pages.

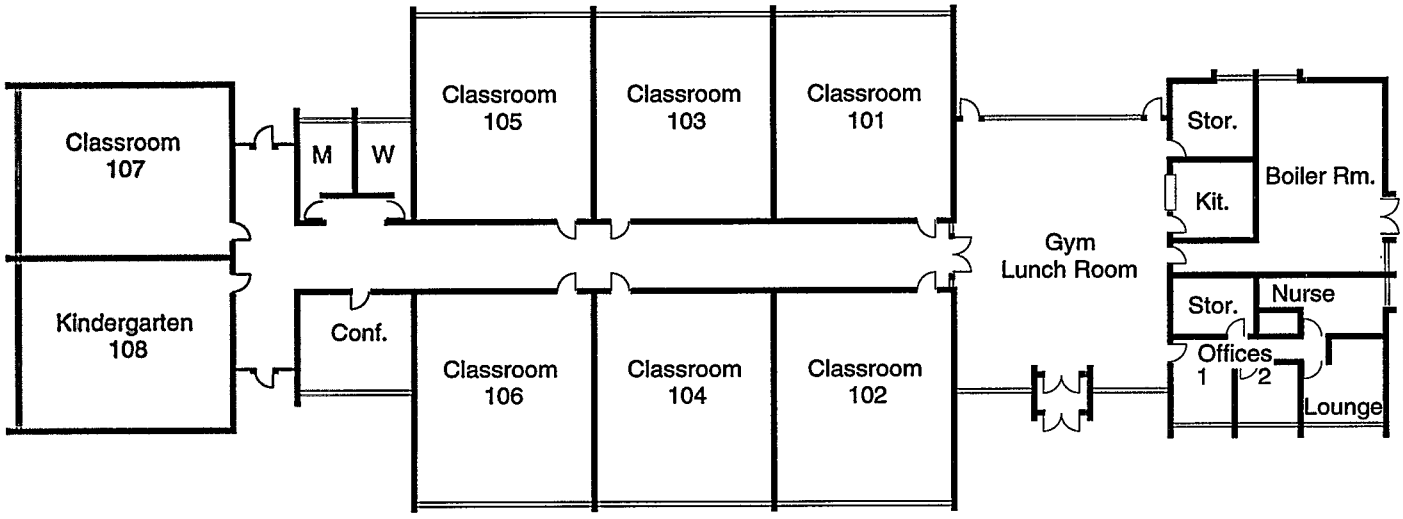


Figure 6-1: Floor Plan of Case Study School.

Preparing for Radon Testing

Use the floor plan you have brought with you or the case study that is presented on the previous page to complete the checklist below (as much as possible). Additional device placement log sheets are provided at the end of this unit.

Step A: Using a Measurement Service

The first step of a measurement program is to select the type of measurement device that you are going to use and the device manufacturer (primary service) that will provide these devices. Call your State Radon Office or EPA Regional Office for a current listing of RMP-listed or State-certified device manufacturers (primary services)—See Appendix A of EPA's guidance document for phone numbers.

For information on selecting a device manufacturer, refer to page 73 (Appendix A) of this workbook.

Complete as much of the procedural checklist as you can.

Step B: Planning a Testing Program

The following is an abbreviated version of the procedural checklist from Appendix F (pages 40-44) of EPA's guidance document:

To help you with steps B-F, a detailed checklist on the radon testing procedure can be found on pages 40-44 of EPA's guidance document which describes each of these steps in detail.

- ❑ **1.** Document the month, approximate date, and day of the week you plan to begin the measurements here:

  _____

  Document the planned retrieval date here:

  _____

- ❑ **2.** Number of rooms to be tested:_____

  Total number of measurement devices (including duplicate and blank devices):_____

You may want to notify the lab analyzing the detectors that a large number of detectors may be sent at one time. This will give the lab time to prepare to handle a large number of detectors.

- ❑ **3.** Contact your State Radon Office to see if your device meets proficiency requirements.

- ❑ **4.** Complete the floor plan, marking each room to receive a detector.

- ❑ **5.** Prepare the Device Placement Logs.

- ❑ **6.** Note on the floor plan which rooms should receive duplicates.

- ❑ **7.** Complete the floor plan with notations for blanks.

- ❑ **8.** Read actual directions for your device supplied by the manufacturer of your device.

Step C: Deploying the Measurement Devices

- ❑ **9.** Briefly describe meetings, informational materials and presentations that you plan to use to notify students and staff of testing.

You may want to consider encouraging parents of students to test their home for radon. Refer parents to their State Radon Office for information on testing a home for radon.

Your State Radon Office may have educational materials on radon that are appropriate for your students.

- ❑ **10.** Complete the first four columns of the log sheet for the first three detectors before you place any detectors.

- ❑ **11.** Remember to intersperse locations for duplicates and blanks on the log sheet (see steps 13 and 16 below).

- ❑ **12.** Complete the log sheet for deployment dates and times.

- ❑ **13.** Note duplicates on the log sheet.

- ❑ **14.** Record duplicate serial numbers and times on the log sheet.

- ❑ **15.** Record serial numbers of blanks on the log sheet but do not deploy them.

- ❑ **16.** Note blanks on the log sheet and give them a fictitious time on the log sheet.

- ❑ **17.** Note start dates and times on the device label if the device has a label.

Step D: Record Keeping During Testing

❑ **18.** Note any unusual weather events during testing.

Step E: Retrieving the Measurement Devices

❑ **19.** Read manufacturer's instructions regarding device retrieval.

❑ **20.** Check location and serial number of each device against what is recorded on the log sheet and note any discrepancies on the log sheet.

❑ **21.** Record the date and time of retrieval for your detectors.

After being opened and exposed to indoor air, activated charcoal detectors and liquid scintillation detectors should be mailed to the laboratory analyzing the detectors within a day after completion of the test.

Make sure activated charcoal detectors and charcoal liquid scintillation detectors reach the lab within 2-3 days.

Step F: Preparing the Device for Analysis

❑ **22.** Break seals on blank detectors, reseal, and mix in with other detectors before shipping.

❑ **23.** Before shipping, make sure all necessary information for each device has been recorded.

❑ **24. Make a special copy of the log sheet for the analyzing laboratory by covering the "Room #/Name" and "Location" columns with the blank piece of paper before copying.** This special copy of your log sheet keeps the identities of the duplicates and blanks masked from the lab.

❑ **25. Include this special copy of the log sheet with the shipment of detectors that were deployed in the school.**

Unit Summary - Implementation of the School Radon Testing Program

This unit provides a walk-through of events in the planning and execution of a radon testing program. The selection of a measurement device, decisions on the rooms to be tested, locations in the rooms to be tested, and times for testing are covered for an actual school. The unit reviews all the steps associated with radon testing in a school building including documentation that is necessary for a successful program.

Device Placement Log

SCHOOL:_____

Room #/Name	Location	Serial #	Start Date	Start Time	Stop Date	Stop Time	Comments	Result

NAME:_____

Device Placement Log

SCHOOL:_____

Room #/Name	Location	Serial #	Start Date	Start Time	Stop Date	Stop Time	Comments	Result

NAME:_____

APPENDIX A

Quality Assurance Plans for Device Manufacturers

Primary services (i.e., an organization that offers radon testing devices) provide the detector and its analysis. These organizations should adhere to quality assurance plans (QAP) that include the following elements.

- calibration of their measurement system, in terms of where, how often, and by whom their equipment is calibrated, and by citing recent calibration results.
- chain-of-custody (detector tracking) procedures.
- routine instrument performance checks (daily or less frequent checks of analytical equipment at the laboratory), and where, how, and by whom the results of these checks are recorded.
- quality assurance management, including the name of the quality assurance officer and how he or she fits into the organization's management structure.
- assessing the inherent error in their measurements via the use of duplicates, blanks, and spikes (procedures should be specific in terms of the frequency, locations, and numeric goals for the results of these measurements).
- corrective action, for situations such as when the results of duplicates, blanks, or spikes do not meet the goals; for when detectors are damaged, returned late; or there are other problems.

Important information on selecting a measurement service, evaluating proposals, and developing a contract can be found on pages 32 and 33 of the EPA guidance document.

Primary Services offer and analyze detectors.

Secondary services place and retrieve detectors.