Health Canada

Guide for Radon Measurements in Residential Dwellings (Homes)

~~(Amended with comments from the FPTRPC November 13th, 2007)~~

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ACKNOWLEDGEMENTS

Health Canada would like to thank the United States Environmental Protection Agency for permission to quote from their radon guidance documents and for their assistance in preparing this document and Arthur Scott for development of the original document.

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1. INTRODUCTION

1.1 Scope and Summary

Thise document is intended for persons or organizations ~~who~~ proposinge to carry out radon measurements into ~~identify~~ residential homes. ~~for remedial action against radon.~~ The purpose of testing for radon is to evaluate the levels in order to determine whether remedial action is required. The scope of this document is limited to guidance regarding types of measurement devices, device placement, measurement duration, and the interpretation of measurement results ~~for radon testing~~ in homes. A separate guide is available for assessing radon in residential public buildings, such as hospitals, schools and long-term care facilities.

1.2 What is Radon?

Radon is a radioactive gas that is formed naturally by the radioactive breakdown of uranium in soil, rock and water. It cannot be detected by the senses, i.e~~.~~ ~~i.~~, it is colourless and odourless; however, it can be detected with special~~measurement~~ instruments. Radon usually escapes from the ground into outdoor air where it mixes with fresh air resulting in concentrations too low to be of concern. However, when radon enters an enclosed space, such as a building, it can accumulate to high concentrations. The only known health risk associated with exposure to radon is an increased risk of developing lung cancer. The level of risk depends on the concentration of radon and length of exposure.

Because the source of most radon in homes is the soil on which the house or building is standing and radon which escapes from the soil and infiltrates a home tends to be heavier than air, higher indoor radon levels are more likely to exist below the third floor. For this reason Health Canada recommends testing all homes below the third floor. In some cases, higher radon levels have been found at or above the third floor, due to radon movement through elevators or other air shafts in the building. If your apartment is at or above the third floor and you are concerned about this possibility, you could also choose to test for radon.

1.3 Radon Guideline

Although there is no regulation that governs an acceptable level of radon in Canadian homes or public buildings, Health Canada, in partnership with the provinces and territories, has developed a guideline. This guideline provides Canadians with guidance on when remedial action should be taken to reduce radon levels. The following guideline was adopted by the Government of Canada on June 9, 2007:

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"Remedial measures should be undertaken in a dwelling whenever the average annual radon concentration exceeds 200 Bq/m^3 in the normal occupancy area.

The higher the radon concentration, the sooner remedial measures should be undertaken.

When remedial action is taken, the radon level should be reduced to a value as low as practicable.

The construction of new dwellings should employ techniques that will minimize radon entry and will facilitate post-construction radon removal, should this subsequently prove necessary."

(See page 9 on units and page 11 on time frame for remediation).

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2. RADON MEASUREMENT DURATION

~~1.3.1~~2.1 Long-Term Measurements

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~~1.3.2~~Radon levels in a home or building can ~~vary~~vary significantly over time. In fact, it is not uncommon to see radon levels in a home change by a factor of 2 to 3 over a 1-day period and variations from season to season can be even larger. The highest radon levels are usually observed during winter months. As a result, a long-term measurement period will give a much better indication of the annual average radon concentration than measurements of shorter duration. **Long-term measurements are typically 3 to 12 months in duration.** During this type of measurement, there are no requirements for the occupants to change their life-style once the measurement devices have been put in place. **Health Canada recommends that the radon test performed in a home or public building be a long-term measurement. Health Canada does not recommend a test of duration less than 1 month, a minimum of 3 months is recommended and 12 months is optimum.**

2.2 Short-Term Measurements

In rare cases, a more rapid indication of the radon concentration may be required. Under such circumstances a short-term measurement of duration less than 3 months (more typically 2 to 7 days) can be performed. However, short-term measurements should be used with caution for the reasons cited above. **Testing durations of less than 2 days (48 hours) are never acceptable to determine radon concentrations for purposes of assessing the need for remedial actions**. Since radon concentrations vary over time, it is strongly recommended that the result of any short-term measurement be confirmed with a "follow-up" long-term measurement. The follow-up measurement should be made at the same location as the initial measurement. **A single short-term measurement is**

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not a sufficient ~~to~~ baseis for a decision to mitigate. In this case a follow-up measurement is always necessary for mitigation decision-making regardless of the initial measurement result.

2.2.1 Conditions for Short-Term Measurements

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Short-term measurements must be made under closed-building conditions to stabilize the radon concentrations and increase the validity of the annual radon concentration estimate. In addition to maintaining closed-building conditions during the measurement, these conditions should be in place for 12 hours prior to the initiation of a measurement lasting less than 4 days, and are recommended prior to measurements lasting up to a week in duration. Closed-building conditions involve ensuring that:

- Windows on all levels and external doors are kept closed for the duration of the test, except during normal entry and exit. Normal entry and exit include a brief opening and closing of a door, but external doors should not be left open for more than a few minutes.
- External-internal air exchange systems such as high-volume, whole-house and window fans are not operated. However, attic fans intended to control attic temperature or humidity may be operated. Combustion or furnace makeup air supplies must not be closed.
- Normal operation of permanently installed energy recovery ventilators (also known as heat recovery ventilators or air-to-air heat exchangers) may continue. In houses where permanent radon mitigation systems have been installed, these systems should be functioning during the measurement period.
- Air conditioning systems that recycle interior air can be operated during the closed-building conditions.

Short-term measurements lasting less than four~~three~~ days should not be conducted during severe storms or periods of unusually high winds. The rapid changes in barometric pressure associated with storms increase the chance of a large difference in the building interior and exterior air pressures, thus changing the rate of radon influx. A high wind increases the variability of radon concentration because of wind-induced differences in air pressure between the building interior and exterior. In either case, the radon concentration during the measurement may not be representative of the average concentration in the building. Weather predictions available on local news stations or weather-reporting websites provide sufficient information to determine if these conditions are likely.

Closed-building conditions generally prevail during the cold season from October to April when the average daily temperature is low enough that windows are kept closed. To provide closed-building conditions outside the cold season, the occupants may have to change their life-style for the duration of the measurement.

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3. RADON MEASUREMENT DEVICES

There are several radon measurement devices that may be used to test a home or building for radon. These devices fall into two broad categories: those used for long-term measurements (testing period of 3 to 12 months in duration) or those designed for short-term measurements (testing period of less than 3 months and more typically 2 to 7 days). The detection methods listed below are currently recognized by Health Canada as acceptable for measuring radon in homes and public buildings.

3.1 Devices for Long-Term Measurements

3.1.1 Alpha Track Detection

These detectors use a small piece of special plastic or film inside a container with a filter-covered opening. Air being tested diffuses (passive detector) or is pumped (active detector) through a filter covering a hole in the container. When alpha particles from radon and its decay products strike the detector, they cause damage tracks. At the end of the test period the container is sealed and returned to a laboratory for reading. The radon exposure duration of an alpha track detector is usually 1 to 12 months.

3.1.2 Electret Ion Chamber

This device consists of a special plastic canister (ion chamber) containing an electrostatically charged disk detector (electret). The detector is exposed during the measurement period, allowing radon to diffuse through a filter-covered opening into the chamber. Ionization resulting from the decay of radon produces a reduction in the charge on the electret. The drop in voltage on the electret is related to the radon concentration. The detectors may be read in the home using a special analysis device to measure the voltage or mailed to a laboratory for analysis. This type of detector may be deployed for 1 to 12 months.

3.1.3 Digital Detector

This detector plugs into a standard wall outlet much like a consumer carbon monoxide detector, and continuously monitors for radon. It is a passive device based on an ion chamber. It allows the homeowner to make radon measurements in different areas of the home. After being plugged in for an initial period of 48 h, the device displays the average radon concentration continuously.

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3.2 Devices for Short-Term Measurements

3.2.1 Activated Charcoal Adsorption

These devices utilize an airtight container filled with activated charcoal and covered with a screen and filter. The detector is opened in the area to be sampled and exposed to the air for a specified period of time. Radon present in the air adsorbs onto the charcoal. At the end of the sampling period, the container is sealed and then sent to a laboratory for analysis using a scintillation detector. Charcoal detectors may be subject to effects from drafts and high humidity. These detectors are normally deployed for measurement periods of 2 to 7 days.

3.2.2 Charcoal Liquid Scintillation

This method is very similar to the activated charcoal detector in that it employs a small vial of activated charcoal for sampling the radon. Following exposure, the vial is sealed and returned to a laboratory for analysis by treating the charcoal with a scintillation fluid, then analyzing the fluid using a scintillation counter. These detectors are also deployed for normal periods of 2 to 7 days.

3.2.3 Electret Ion Chamber

This is the same device described for long-term tests. However, variations in the design of the electret allows for a short-term measurement as well. The short-term electret ion chamber is deployed for 2 to 7 days.

3.2.4 Continuous Radon Monitoring

This detection category includes devices that record real-time continuous measurements of radon gas over a series of minutes and report the results in hourly increments. Air is either pumped or diffuses into a counting chamber, typically a scintillation cell or ionization chamber. The result using this type of detector is normally available at the completion of the test in the home or building without additional processing or analysis. These detectors are normally deployed for a minimum of 48 hours.

3.2.5 Continuous Working Level Monitoring

These devices record real-time continuous measurement of the radioactive decay products of radon in the air.~~decay products.~~ Radon decay products are sampled by continuously pumping air through a filter. Alpha particles from the decay of products trapped on the filter are counted to determine the concentration of radon decay products in the air sampled. Continuous working level monitors should be deployed for a minimum of 48 hours.

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4. SPECIALIZED MEASUREMENT DEVICES

A number of other specialized measurement methods are also available for radon testing. However, they all require a skilled technician and/or specialized analytical equipment to achieve proper sampling results. These requirements tend to make these measurement methods more expensive than those previously described, and thus they are not commonly used for radon testing in homes or public buildings. Instead, these methods find greater application in research work or to evaluate the success of radon reduction efforts. A list of these methods is provided for information purposes. The methods listed may only be used for short-term measurements.

1. Grab Radon/Activated Charcoal

2. Grab Radon/Pump-Collapsible Bag

3. Grab Radon/Scintillation Cell

4. Three-Day Integrating Evacuated Scintillation Cell

5. Pump-Collapsible Bag (1-day)

6. Grab Working Level

7. Radon Progeny (Decay Product) Integrating Sampling Unit

5. UNITS OF RADON MEASUREMENT

Canada, like most other countries, has adopted the International System of Units (SI units) and thus the radon guideline is given in units of ~~becquerels~~Becquerel per cubic meter (Bq/m^3). Therefore, in order to be able to compare a radon test result to the radon guideline, **radon measurements must be made in units of Bq/m^3** or the appropriate conversion must be applied ~~Canada, like most other countries, has adopted the International System of Units and thus the radon guideline is given in units of Bq/m^3. Therefore, in order to be able to compare a radon test result to the radon guideline, **radon measurements must be made in units of Bq/m^3** or the appropriate conversion must be applied~~to non-SI units (see table below).~~.~~

However, the following information is provided: Depending on the measurement device used to complete a test, the measurement results may be in one of 3 units. ~~Test results from devices that measure concentrations of radon gas are provided as Becquerels per cubic metre (Bq/m^3) or picoCuries per Liter (pCi/L). One pCi/L is equal to 37 Bq/m^3, thus 200 Bq/m^3 is roughly equivalent to 5.4 pCi/L. For devices that measure the radiation emitted from radon progeny, results will be given as Working Levels (WL) or~~

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Type of device	Units used	Comments~~Conversion~~
Devices that measure concentrations of radon gas	Becquerels per cubic metre (Bq/m^3~~)~~) (Canada)	1 Becquerel is equal to 1 disintegration per second
~~Devices that measure concentrations of radon gas~~	picoCuries per Liter (pCi/L)~~.~~ (Unite~~d~~s States)	~~1~~5.4 pCi/L is equal to ~~37~~200 Bq/m^3
D~~For d~~evices that measure the radiation emitted from radon progeny	Working Levels (WL) or milliWorking Levels (mWL)	Conversion from WL to Bq/m^3 requires accurate knowledge ~~-~~of contingent ~~the~~ factors~~.~~ ~~that influence the conversion factor~~

Note: Care must be exercised in converting from units of radon progeny to radon gas as the ratio between the units depends on a number of factors~~.~~ ~~Conversion from WL to Bq/m^3~~

6. MEASUREMENT IN HOMES

6.1 Measurement Strategy

Health Canada recommends the placement of at least one long-term detector in a home for a minimum of 3 to 12 months (12 months is optimal). For periods less than 12 months, the testing period should include a mix of seasons or be in a mid-season to best provide a measurement that reflects the annual average level. The ideal 3 month testing period would be in the typical heating season that runs from October thru to April. The least ideal period is during the summer since open window conditions often prevail.

6.2 Measurement Locations

To provide a realistic estimate of the radon exposure of the occupants, all measurements should be made in the normal occupancy area of the lowest lived-in level of the home. The normal occupancy area is defined as any area occupied by an individual for more than 4 hours per day.

Potential measurement locations include family rooms, living rooms, dens, playrooms and bedrooms. A lower level bedroom is preferred because people generally spend more time in their bedrooms than in any other room in the house. Similarly, if there are children in the home, lowest level bedrooms or other areas such as a playroom are preferred.

- Place the device by an interior wall at least 50 cm (20 inches) from the floor and at least 10 cm (4 inches) from other objects. The best height is 0.5~~8~~ to 2 metres (~~3~~1.5 ~~-~~to 6.5 feet) from the floor since it represents the typical breathing zone.~~.~~

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- Measurements should not be made in kitchens or laundry rooms. Kitchen exhaust fan systems and airborne particles (caused by cooking) may affect some measurement devices.
- Measurements should not be made in bathrooms because relatively little time is spent in a bathroom, high humidity may affect some measurement devices, and use of an exhaust fan may temporarily alter radon concentrations.
- Measurements should not be made in closets, cupboards, sumps, crawl spaces or nooks within the foundation. Radon concentrations in these areas are not representative of the concentration in the occupied area of the house.

The location should not be in air currents caused by heating, ventilating and air conditioning vents, doors, fans and windows. Locations near heat, such as over radiators, near fireplaces or in direct sunlight, should be avoided as some measurement devices may be affected. Similarly devices should not be placed on or near electrically powered equipment or appliances such as the tops of televisions, stereos or speakers.

Homeowners should always consider re-testing whenever major renovations are performed that might substantially change the ventilation or airflow in the home or the use of the rooms in the lowest-occupied level. For example, a home that undergoes basement refinishing should be re-tested in the basement assuming the original test was performed on another level (main floor).

~~1.6~~7. INTERPRETATION OF MEASUREMENT RESULTS

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~~1.6.1~~7.1 Long-Term Measurements in Homes

If the long-term measurement results are less than~~below~~ 200 Bq/m^3, the average annual concentration in the home ~~or building~~ is probably below 200 Bq/m^3. ~~and f~~Further measurements are not necessary and remedial action is not recommended.

If the long-term measurement results are greater than 200 Bq/m^3, then the average annual concentration in the home or building is probably above 200 Bq/m^3 and remedial action is recommended.

~~1.6.2~~7.2 Short-Term Measurements in Homes

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The result of any initial short-term measurement (regardless of the result) should be confirmed with a "follow-up" long-term measurement. The follow-up measurement should be made at the same location as the initial measurement.

If the result of the long-term follow-up measurement is greater than 200 Bq/m^3, then remedial action is recommended.

If the result of the long-term follow-up measurement is less than 200 Bq/m^3, then remedial action is not recommended.

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8.

-TIMEFRAME TOimeframe to RremediateEMEDIATE

Radon Concentration	Recommended remedial action time
Greater than 600 Bq/m^3	In less than 1 year
Between 200 Bq/m^3 and 600 Bq/m^3	In less than 2 years
Less than 200 Bq/m^3	No action required

~~Excerpt from Radon Guideline re timeframe~~

The responsibility for remediation, and for its associated costs, rests with the owner of the building.

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ANNEX 1

Radon Measurement

Procedure

For

Residential Dwellings (Homes) ~~Residential Dwellings (Homes)~~

Where ~~Area~~ to Test

Place the radon detector in the normal occupancy area of the lowest lived-~~-~~in level of the home.

IF ~~IF~~ the basement has finished rooms such as bedroom, playrooms, family room,

~~T~~**THEN** place the device in the area occupied for more th~~a~~en 4 hours each day.

I~~I~~F the basement does **not have** any areas where people work-, play or sleep,

THEN- test on the -main level.

~~NOTE: Do not place the detector in kitchen, laundry rooms, bathrooms, closets, cupboards, sumps, crawl spaces or nooks within the foundation.~~

Where to Locate the ~~Location of~~ Detector

Radon d~~D~~etectors should be placed more than 50 centimetres from any floor, wall or ceiling, and more than 10 centimetres from other objects so as to allow normal airflow around the detector.~~by an interior wall~~

- ~~at least 50 centimeters (20 inches) from the floor and~~
- ~~at least 10 centimeters (4 inches) from all other objects~~

(The best height to place a detector at is 0.5~~8~~ to 2 meters (1.5~~3~~ to 6.5 feet)).~~)~~

Do ***not*** place the detector in kitchens, laundry rooms, bathrooms, closets, cupboards, sumps, crawl spaces or nooks within the foundation.

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~~NOTE:~~ Do ***not*** place detector by heating, ventilating and air conditioning vents, doors, fans, windows, fireplaces, ~~in direct sun,~~ electrically powered equipment, on~~tops~~ ~~of~~ television sets~~s~~, stereos or speakers, or~~.~~ in direct sunlight.

Reading the detector

After the monitoring period of 3 to 12 months the detector is returned to the supplier for processing and evaluation of radon concentrations.

- **IF** the long-term measurement results are **less than~~below~~ 200 Bq/m^3**,
- **THEN** remedial action to lower radon concentrations in the home **is not** recommended.
- **IF** the long-term measurement results are **greater than 200 Bq/m^3**,
- **THEN** remedial action to lower radon levels **~~are~~ s** recommended.

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~~*Glossary of Terms*~~

~~Scintillation Fluid~~

~~Scintillation Counter~~

~~Radon Influx~~

~~Remediate~~

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