NRRC Stakeholder Guidelines

Kingdom of Saudi Arabia

The National Unified Protocol for Radon Measurements in Dwellings and Public Buildings

NRRC-SG-021

2026

هيئة الرقابة النووية والإشعاعية
Nuclear and Radiological Regulatory Commission

Stakeholder Guideline
The National Unified Protocol for Radon Measurements in Dwellings and Public Buildings

2026
NRRC-SG-021

Preamble

In accordance with the provisions of the NRRC's approved regulations, this stakeholder guideline describes the technical protocol for the measurement of Radon gas in dwellings and public buildings and describes the criteria and/or techniques that are considered appropriate for satisfying the requirements stipulated in the NRRC's regulations.

This stakeholder guideline has been prepared in consistent with International Atomic Energy Agency (IAEA) standards, international best practices, and in accordance with the Kingdom's international commitments.

This stakeholder guideline has been approved by the NRRC's CEO resolution No. 0310806 dated 19/4/2026.

Contents

1.	**Introduction**	**7**
1.1	Purpose	7
1.2	Scope	8
1.3	Definitions	8
1.4	Abbreviations	10
1.5	Radon Gas	10
1.6	The Importance of Measuring Radon Levels	13
1.7	NRRC Radon Regulation	14
2.	**General Considerations and Recommendations**	**15**
2.1	Measurement Conditions and Strategy	15
2.2	Measurement Duration	17
2.2.1	Seasonal	17
2.2.2	Long-term Measurement	18
2.2.3	Short-term Measurements	18
2.2.4	Follow-up Measurement	18
2.3	Radon Measurement Techniques	19
2.4	Measurement Devices	19

2.5	Calibration Recommendations	20
2.6	Measurement Uncertainty	20
2.7	Minimum Detectable Activity Concentration	21
2.8	Reporting and Documentation Guidelines	21
2.9	Quality Assurance	22
2.10	Actions When Reference Levels are Exceeded	22
2.11	Control Measurements After Remedial Actions	23
3.	**Measurement Protocol in Dwellings**	**24**
3.1	Conducting the Measurement	24
3.1.1	Measurement Period Length	24
3.1.2	Time of Measurement	24
3.2	Location Selection	25
3.2.1	Placement of Detectors in the Dwelling	25
3.2.2	Placement of Detectors in the Room	25
3.2.3	Selection of Apartments in Multi-Family Buildings	26
3.3	Information for Residents	26
3.4	Calculation of Average Value	27
3.4.1	Dwellings on One Floor	27
3.4.2	Dwellings on More Than One Floor	27

3.4.3	Estimation of Annual Average Value	28
3.5	Reporting Measurement Results	28
3.6	Comparison with Reference Levels Values	28
4.	**Measurement Protocol in Public Buildings**	**30**
4.1	Conducting the Measurement	30
4.1.1	Measurement Time and Period	30
4.1.2	Placement of Radon Detectors in Property	30
4.1.3	Number of Measurement Points	31
4.2	Information to Employees	31
4.3	Measurement Values Report	32
4.4	Comparison with the Reference Level	32
5.	**Protocol for Measuring Radon in Schools**	**35**
5.1	Radon Measurement	35
5.2	Selection of Measurement Location	36
6.	**Related Documents and Files**	**37**
Annex I: Common Methods for Radon Measurements		**38**
I.1	The protocol for the Electret Ion Chamber	38
I.2	The Protocol for Alpha Track Detectors	39
I.3	The Protocol for Continuous Radon Monitors	41

1. Introduction

1.1 Purpose

The objective of this stakeholder guideline is to present standardized technical protocols for measuring radon gas concentrations in buildings with consistent procedures to ensure accurate and reproducible measurements. It also enables valid intercomparison of measurement results from different studies, including dwellings, workplaces, schools, and public buildings, and ensures these measurements are below the reference levels as set in the NRRC regulations.

The protocols explain how to perform measurements of radon gas concentration in these properties and how to estimate the annual average levels based on the measurement results, which can be considered the building's annual average activity concentration and can be compared with the regulations' reference levels set by NRRC.

These protocols provide method-specific technological guidance, used as the basis for standard operating procedures for any Technical Services Organization using radon and radon decay product measurement methods. In keeping with good laboratory practices, each radon measurement laboratory should develop its own detailed instrument-specific procedures that incorporate recommendations found in this stakeholder guideline.

Another aim is to specify how the annual average radon

concentration is determined at dwellings and public buildings, so that the value can be used as a basis for the right decisions.

1.2 Scope

The scope of this stakeholder guideline is to present guides regarding types of measurement methodologies, device placement, measurement duration, multiple measurements, and the interpretation of measurement recommendations to ensure that radon gas measurements can be conducted with high quality and precision in dwellings, workplaces, schools, and public buildings. NRRC regulates the reference level in workplaces in its Regulation on National Radon Reference levels in Dwellings and Public Buildings (NRRC-R-01-SR10). This stakeholder guideline applies to indoor workplaces, including finished underground facilities. However, it does not cover mines or underground facilities under construction.

1.3 Definitions

Ambient dose equivalent, H*(d)

The dose equivalent that would be produced by the corresponding aligned and expanded field in the International Commission on Radiation Units and Measurements (ICRU) sphere, at a depth "d" on the radius vector opposing the direction of the aligned field, expressed in units of micro-sieverts per hour ($\mu Sv \cdot h^{-1}$).

Exposure

The state or condition of being subject to irradiation.

Minimum Detectable Activity (MDA)

The lowest detectable radioactivity concentration produces a measurement value that, with a certain probability, exceeds the background level of the measuring system.

Radioactivity Concentration

The activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed, expressed in units of becquerel per cubic meter ($Bq \cdot m^{-3}$).

Radon

Any combination of isotopes of the element radon, and for the purposes of the NRRC regulations, radon refers to 220Rn and 222Rn.

Reference levels

For an emergency exposure situation or an existing exposure situation, the level of risk or radioactivity (A) concentration above which it is not appropriate to plan to allow exposures to occur, and below which optimization of protection and safety would continue to be implemented.

Technical Services Organizations

An organization that provides expertise and services to support nuclear and radiation safety and all related scientific and technical issues.

1.4 Abbreviations

ABBREVIATION	DEFINITION
NRRC	Nuclear and Radiological Regulatory Commission.
EIC	Electret Ion Chamber.
AT/ ATD	Alpha Track/ Alpha Track Detector.
CR / CRM	Continuous Radon/ Continuous Radon Monitoring.
QC	Quality Control.
MDA	Minimum Detectable Activity.

1.5 Radon Gas

Radon is an invisible, odorless, and naturally occurring radioactive gas that is formed by the breakdown of uranium and thorium's natural radioactive decay series in soil and rocks and cannot be detected by the senses. Radon gas is considered harmless when dispersed in outdoor air but can be a serious health hazard when trapped in buildings.

Radon (Radon-222) and thoron (Radon-220) are gaseous radioactive materials produced through the radioactive decay of radium ore. They enter the human body through inhalation. Radon results from the decay of Radium-226 produced in a

decay chain (uranium series) that starts from Uranium, and thoron results from the decay of Radium-224 produced in a decay chain (thorium series) that starts from Thorium-232. Radon has a half-life of approximately 3.8 days, and thoron has a half-life of approximately 55 seconds.

Radon and its progeny nuclides are the most significant contributors to natural radiation exposure. Due to radon and thoron diffusing into the air from the ground, building materials, etc, people inhale radon and thoron in their lives on a daily basis. Inhaled radon reaches the lungs and emits α-particles, causing internal exposure of the lungs. Furthermore, it decays into progeny nuclides, which then migrate from the lungs and the esophagus to the digestive organs together with sputum, causing further internal exposure.

Radon, being a gas, is easily exhaled, which means that its progeny nuclides contribute less to internal exposure compared to the progeny themselves. i.e., radioactive Polonium-218 and Lead-214 that are created through decay of the former, are solids and therefore not easily expelled out of the body once inhaled, as they adhere to the alveoli and the bronchial wall surface.

Radon combines with fresh air when it leaks from the ground to the outdoors, resulting in concentrations too low to be of concern. When radon enters an enclosed space, such as a home, it can accumulate to high concentrations and become a health concern. Radon can enter a home when an opening area is

found where the house contacts the soil: cracks in foundation walls and in floor slabs, construction joints, gaps around service pipes, support posts, window wells, floor drains, sumps, or cavities inside walls, as shown in Figure 1.1.

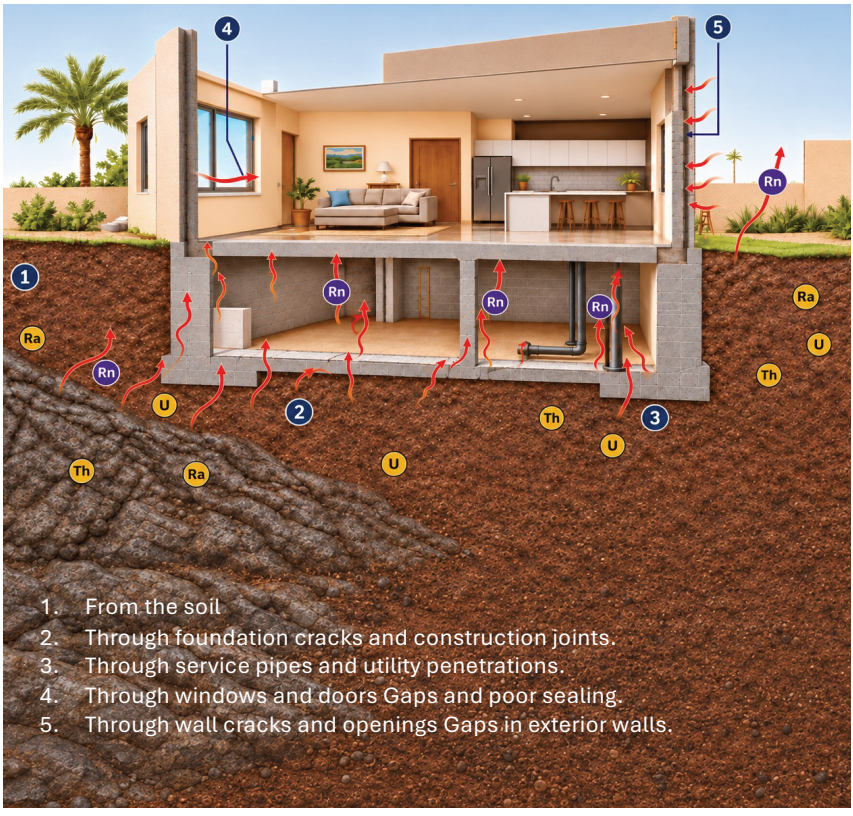

Figure 1.1: An illustration of various radon entry routes to houses

1.6 The Importance of Measuring Radon Levels

The known health risk associated with long-term exposure to radon and its decay products is an increased risk of developing lung cancer. The level of risk depends on the concentration of radon and duration of exposure. The measurement of the radon gas concentrations in buildings is very important to identify areas that have high concentrations of this gas, since it may pose a significant health threat to the public. It is extremely important that homes and other buildings be tested to determine if elevated radon levels are present indoors.

Radon exposure is especially concerning for miners who work in radon-rich environments underground. Studies conducted since the 1950's have revealed significantly higher lung cancer rates among miners, leading to concerns about residential radon exposure. Since then, epidemiological research has shown that even low levels of long-term radon exposure in homes can significantly increase the risk of lung cancer, and smoking will further compound this risk. The studies found that individuals exposed to over 200 $Bq{\cdot}m^{-3}$ of radon who also smoked had a 29.3% higher risk of lung cancer.

In conclusion, radon exposure is a well-established risk factor for lung cancer, but its association with non-lung cancers remains unclear. While some studies suggest biological plausibility and potential links to cancers such as skin, stomach, and leukemia,

the evidence is inconsistent. Future research should focus on more accurate radon exposure measurements and controlling for confounding variables to determine whether radon poses a significant risk for non-lung cancers. In the meantime, radon mitigation efforts should prioritize lung cancer prevention, given strong evidence supporting this link.

1.7 NRRC Radon Regulation

The NRRC issued the Regulation on National Radon Reference levels in Dwellings and Public Buildings (NRRC-R-01-SR10) to establish the indoor air radon reference levels for dwellings and public buildings as listed in Table 1.1.

Table 1.1: The national reference levels of indoor radon concentration in buildings

Building Type	Reference Level ($Bq \cdot m^{-3}$)
Existing dwellings	300
New dwellings	200
Public buildings, schools, and workplaces*	300

* It does not apply in workplaces where occupational exposure to other radionuclides in the ^{238}U decay series or the ^{232}Th decay series is controlled as a planned exposure situation.

2. General Considerations and Recommendations

2.1 Measurement Conditions and Strategy

Before conducting a radon test, the following actions should be taken:

- Inform building occupants of proper testing conditions. Explain the guidance for occupants and give them a hard and/or soft copy of the instructions.
- Be sure to use a qualified radon measurement device if you conduct the test yourself and follow measurement instructions.
- If you are not conducting the test yourself, ask a Technical Services Organization.
- Record the personal information (Name, City, National address).
- Record the device information (Manufacturer/Model, Serial No., test national address (coordination), the exact location of the device, on a diagram of the room and building if possible).
- Record the measurement place information (type of building/floor, building material, flooring type, type of paint, measurement room type, room size (length x width x height), type of ventilation, type of cooling system, type of heating system).
- Record the measurement test conditions (Temperature, Humidity, Dusty weather or place, Condition required for short-term measurement).

- Choosing the correct location within a room, taking into account these considerations when you are placing the detector inside the room:
  - Choose a place in the room that is mostly unoccupied so as not to move the detector, change its location, or change its performance during the measurement period.
  - The detector should be placed 50 cm above the floor, and at least 30 cm below the ceiling of the room.
  - The detector should be placed at least 30 cm from the walls of the room.
  - The detector should be kept at least 90 cm away from doors, windows, and possible openings to the outside at dwellings and 150 cm from air inlets, exterior doors, windows, air conditioners, or any other heat sources, and not closer than 50 cm from exhaust outlets at public buildings.
  - The distance between the detector and objects or any other detector should not be less than 10 cm.
  - The distance between the detectors that are used for QC purposes should not be greater than 20 cm from the other detectors that are used in the measurement.

The detector should not be located:

- In closed rooms with very high humidity, such as bathrooms, laundry rooms, and kitchens, unless it is unaffected by humidity.
- Near drafts, such as in front of air conditioners, fans, and

open windows.

- Near to heat sources such as a heater, fireplace, and in direct sunlight.
- Inside drawers, cabinets, and sumps.
- Near objects that may imitate radiation (rock collections, granite, etc.).
- During the Radon Test:
- Record the measurement start date and time.
- Set the building condition (heating and cooling) as normal.
- Apply close building conditions for short-term measurement.
- Do not move or disturb the measurement device.
- Record any note e.g. (Unusual severe weather events occurred during the test period, device moving to another location; stop the measurement).
- At the end of measurement period, record the measurement end date and time.

2.2 Measurement Duration

2.2.1 Seasonal

A measurement period that lasts an entire season, such as the winter season's measurement period, should be measured for at least two months. That is because indoor radon levels are high where the doors and windows are closed most of the time, there is no good ventilation, and heating systems are used.

2.2.2 Long-term Measurement

To estimate an annual average radon level that can be compared with the reference value, long-term measurements should be carried out over at least two months during the winter season.

2.2.3 Short-term Measurements

Short-term measurements are useful for preliminary checks after remedial actions have been taken to reduce radon levels. They can also help identify areas requiring long-term measurements or determine the cause of elevated radon levels. Short-term measurements should be conducted over at least five school days, or for a custom duration based on specific needs. However, they cannot substitute long-term measurements when estimating an annual average radon level.

2.2.4 Follow-up Measurement

Follow-up measurements can provide more accurate radon levels during the actual hours when students or children are present. These are particularly useful if the initial long-term measurement exceeds the reference value but does not reflect conditions during the occupied hours.

In schools or preschools with time-controlled ventilation, radon levels can be overestimated if ventilation is turned off outside of regular hours (e.g., evenings, nights, weekends). In these cases, follow-up measurements can be crucial.

2.3 Radon Measurement Techniques

Radon measurement techniques are classified based on whether or not an external power source is used during the sampling.

a. Passive Devices

Passive devices are integrating devices for measuring radon average concentrations over a long time by diffusing or depositing the radon without energy supplied. Alpha-track Detector (ATD), Activated Charcoal Detector (ACD), and Electret Ion Chamber are some popular choices for home radon measurement, and their prices range from low to medium.

b. Active Devices

Active devices use an external power source for sampling and can provide changes in radon concentration and fluctuations during the measurement period. Electronic Integrating Device (EID) and Continuous Radon Monitor (CRM) the most popular radon active measuring devices and their prices range from medium to high.

2.4 Measurement Devices

The devices and equipment used for measuring indoor radon should meet the recommendations outlined in Annex I for some common techniques for measuring radon-222 and radon decay products. Measurement systems should be calibrated and verified for their precision.

2.5 Calibration Recommendations

All measurement equipment should be calibrated at least once every year, and calibration should be traceable to international standards. The calibration should take into account factors such as ambient conditions (temperature, humidity) and ensure that the equipment is functioning correctly over its expected range of use.

To ensure high-quality measurement results, radon concentration measurements should follow the recommendations of SASO-ISO 11665-2021, where applicable. The technical instructions for each measurement system should also be strictly adhered to. Measurement systems used for radon monitoring should be calibrated to measure radon concentration (Bq/m^3) with traceability to international standards. This means that the calibration should be linked to a recognized reference standard, ensuring accuracy and reliability. Calibration of electronic measuring devices (e.g., radon instruments) should occur before the equipment is put into use and after any repairs or modifications that may affect the device's performance. Regular calibration should be performed at intervals of no more than one year.

2.6 Measurement Uncertainty

Measurement uncertainty arises from several sources, including the measurement process, the calibration factor, and the natural variability of radon concentration. To ensure reliable results,

measurement uncertainty should be calculated and reported alongside the measured radon concentrations.

The expanded measurement uncertainty (with a coverage of 2 sigma) for the measured radon concentration should be determined and presented clearly in the measurement report. In addition, Technical Services Organizations should ensure that the uncertainty of their measurements falls within the acceptable limits defined in this stakeholder guideline.

2.7 Minimum Detectable Activity Concentration

The minimum detectable activity concentration (MDA) should also be calculated. If the measured radon concentration is below the MDA, the result should be reported as "<MDA". The process used to estimate both the measurement uncertainty, and the MDA should be documented.

2.8 Reporting and Documentation Guidelines

The following information should be required in radon measurement reports:

1. The name and address of the measurement party conducting the radon measurement.
2. A description of the measurement methodology, including details of the calibration and control procedures used.
3. An explanation of how the measurement was performed, including the duration of the measurement period and the

placement of the detectors.

4. Details about the workplace, such as floor plans, ventilation types, and any potential radon sources (e.g., building materials).
5. Results of the radon measurement, including the calculated annual average concentration.
6. If applicable, the exposure calculations are based on the working hours and the radon concentration.
7. Reports should be signed by the responsible party conducting the measurement, and the accuracy of the reported data should be certified.

2.9 Quality Assurance

To ensure the reliability and integrity of measurement data, the following are some important quality assurance measures:

1. Detectors calibration and standardization.
2. Gamma background measurements for EIC.
3. Documentation and recordkeeping.
4. Technical Services Organizations.

2.10 Actions When Reference Levels are Exceeded

If long-term measurements show radon levels above the reference levels at one or more measurement points, but those levels do not represent the environment during student or child occupancy, follow-up measurements should be taken at those points to assess

radon levels during the occupied period.

The follow-up measurement results can be combined with the long-term measurements to estimate the annual average during occupancy. Before this estimation is done, it is important to review the follow-up results for accuracy. This review should be performed by the responsible party for the radon measurements, following the quality control standards outlined in the workplace measurement guide.

Follow-up measurements should be conducted either during or shortly after long-term measurements, and under similar conditions. If the reference level is still exceeded after follow-up measurements, remedial actions should be taken as soon as reasonably possible to lower the radon levels.

2.11 Control Measurements After Remedial Actions

After the building or property has been modified to lower radon levels, control measurements should be performed to verify the effectiveness of the actions taken.

Short-term measurements can be used immediately after the remediation to assess the results quickly. However, long-term measurements should always be conducted to establish the annual average radon level, which is necessary for regulatory decisions. Long-term measurements should be repeated at all initial measurement points to confirm that radon levels have decreased in previous high areas and ensure that radon levels

have not increased in other areas.

3. Measurement Protocol in Dwellings

3.1 Conducting the Measurement

3.1.1 Measurement Period Length

To estimate the annual average radon concentration, the measurement should be conducted for at least two months during the same weather season. If possible, measurements should be carried out over a more extended period. The measurement method used should provide a measurement uncertainty of no more than 10% at 300 $Bq \cdot m^{-3}$.

3.1.2 Time of Measurement

Radon levels should be measured during the winter season so that the results can be compared with reference level values. Natural ventilation creates a pressure difference that causes air from the ground to be drawn into the building. When the temperature differential between indoors and outdoors is minimal, natural ventilation is less effective, which affects both air exchange and the infiltration of radon from the ground.
In dwellings with mechanical ventilation, radon levels should also be measured during the winter season. Measurements in unheated dwellings cannot be used as a basis for estimating the annual average.

The entire measurement period should ideally take place within the winter season, but in exceptional cases, it is acceptable for a small part of the measurement, up to approximately 20%, to extend beyond the winter season, provided that at least two months fall within the winter season.

3.2 Location Selection

3.2.1 Placement of Detectors in the Dwelling

Radon detectors should be placed so that the measurement value is representative of the radon levels in the dwelling. Two measurements should be used in separate rooms in houses and apartments on one level, such as the living room and bedroom. For small apartments, one measurement point is sufficient, but two detectors are required at that point. In homes with multiple floors, measurements should be taken on each floor that contains living space. Measurements should only be performed in living areas.

However, they should not be carried out in rooms where windows are open for several hours a day. If they are, this should be noted in the measurement report. Integrated detectors should not be moved from one room to another for any type of dwelling.

3.2.2 Placement of Detectors in the Room

Detectors should be placed in a way that best reflects the

conditions experienced by the residents as described in Section 2.1, and any deviations from this stakeholder guideline should be noted in the measurement report.

3.2.3 Selection of Apartments in Multi-Family Buildings

For radon measurements in multi-family buildings, a selection of apartments can be measured to assess the radon levels in the property, providing an annual average for each of the apartments tested.

Measurements should be conducted in all apartments with ground contact. Ground contact refers to spaces located directly on the foundation slab. Radon measurements should also be performed in apartments where the building materials may contribute to elevated radon levels.

In higher floors, measurements should be conducted in at least one apartment per floor. The measurements should cover at least 20% of the apartments in each building block. Apartments adjacent to elevator shafts, ventilation shafts, or other vertical spaces within the building should be selected, as radon from the ground can rise through these spaces.

3.3 Information for Residents

The party responsible for conducting the radon measurement services should inform residents about all essential details necessary for accurate measurement. This includes advising residents to

maintain normal living conditions during the measurement, such as regular ventilation and maintaining indoor temperature.
If the detectors are sent to the residents for placement, they should be accompanied by detailed instructions on how to perform the measurement and manage the dwelling during the measurement period. The party responsible for conducting the radon measurement services should be available to answer any questions from the residents. The residents should confirm, either by written or electronic signature, that they followed the instructions during the measurement.

3.4 Calculation of Average Value

The calculation of the annual average radon concentration varies depending on the number of floors in the dwelling.

3.4.1 Dwellings on One Floor

The average is calculated from the measurement results and points in the dwelling. At least two measurement points for studio apartments are used; where measurements are taken at a single point, the average from the two detectors is used.

3.4.2 Dwellings on More Than One Floor

If more than one detector was used on each floor, the average is first calculated for each individual floor. The overall average for the dwelling is then calculated based on the averages from each floor.

If the measured value for any room is below the MDA, the recorded value should still be used in the average calculation. Negative values in these calculations should be replaced with zero.

3.4.3 Estimation of Annual Average Value

The annual average value should be considered equal to the dwelling's average value for the measurement period calculated as described in previous sections, and provides the conditions in the sections of calibration, controls, and the period of measurement length are met. If the annual average value cannot be calculated, the reason should be stated.

3.5 Reporting Measurement Results

Radon concentration should be reported in Becquerel per cubic meter unit ($Bq \cdot m^{-3}$). Measurement values and the boundaries of measurement uncertainty should be rounded to the nearest ten. If the values that are to be reported fall below the MDA, they should be indicated as being less than the MDA value. The measured values can be provided in parentheses and should be explained. MDA should be estimated, and the estimation of the random measurement uncertainty and MDA value should be documented.

3.6 Comparison with Reference Levels Values

Comparison between the annual average and the reference

levels in dwellings established by Regulation on National Radon Reference levels in Dwellings and Public Buildings (NRRC-R-01-SR10) and the rounding method should be applied. Figure 3.1 shows a flowchart explain the actions needed for indoor radon measurement in dwellings.

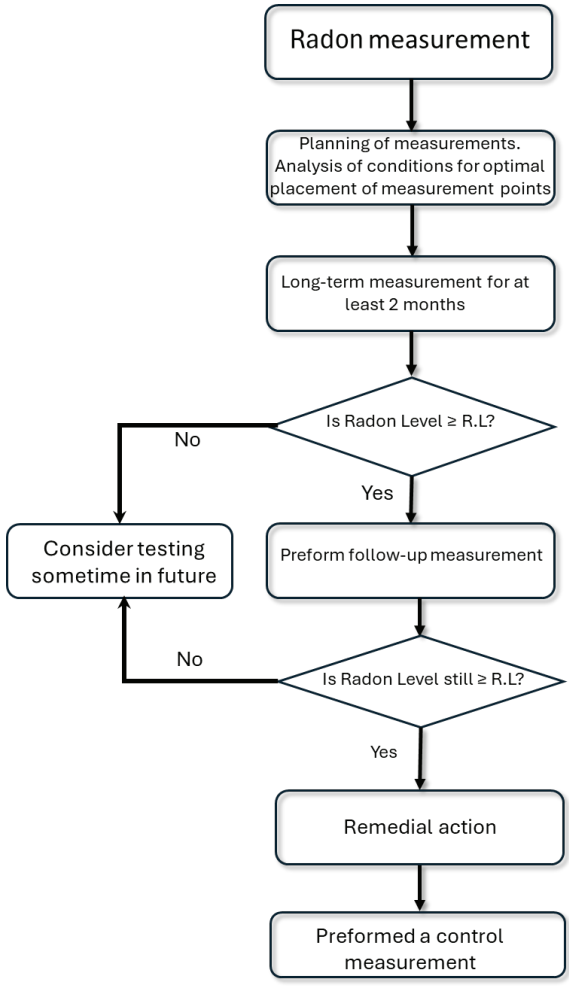

Figure 3.1: A flowchart explaining the actions needed for indoor radon measurement in dwellings

4. Measurement Protocol in Public Buildings

Employers are legally responsible for ensuring a safe work environment, including monitoring radon levels in the workplace. Measurements should be conducted if no prior measurements exist or if more than ten years have passed since the last test. Additionally, new measures are required after structural modifications that may affect radon levels, such as changes to heating or ventilation systems, or any construction work on foundations or basement walls.

4.1 Conducting the Measurement

4.1.1 Measurement Time and Period

Radon measurements should generally be conducted during the winter season, preferably from November 1st to April 30th, to ensure the most accurate representation of radon levels. Measurements should last at least two months (60 days) to capture a reliable representation of radon concentration. Alternatively, continuous measurements over the course of a year may be taken using integrated or time-resolved methods.

4.1.2 Placement of Radon Detectors in Property

Besides the general considerations in Chapter 2, radon detectors should be placed in areas that best represent the working conditions where employees are exposed to radon.

4.1.3 Number of Measurement Points

The number of measurement points should be sufficient to capture the radon concentration in various parts of the workplace. The goal is to provide a comprehensive understanding of radon exposure in the building, while balancing the need for reasonable coverage with the number of measurement points. For buildings with multiple floors or different ventilation systems, radon concentration should be measured on each floor. At least two measurement points should be used per building, and for floors in direct contact with the ground; measurements should be taken in at least one in every fifth room used as a workspace, with at least one point per 200 square meters (200 m^2). If the building has large open spaces (e.g., warehouses or sports halls), fewer measurement points may be acceptable, provided the conditions throughout the space are consistent and homogeneous. In such cases, one measurement point per 1,000 square meters (1,000 m^2) may be sufficient.

4.2 Information to Employees

During radon measurements, the workplace should operate as usual. This includes normal working conditions, with ventilation and heating systems running as they would typically. Employees should also be informed that they should continue their work

activities as normal, without changing habits such as window opening or adjusting room temperature.

4.3 Measurement Values Report

The measured radon concentrations should be reported in the unit Becquerel per cubic meter ($Bq \cdot m^{-3}$). Both the measurement values and their associated uncertainties should be rounded to the nearest ten.

If the reported values are below the MDA, they should be presented as "<MDA". These values can be shown in parentheses in the report and should be explained accordingly.

The radon exposure, which is calculated by multiplying the radon concentration by the time spent in the workplace, should be reported in becquerel-hours per cubic meter ($Bq \cdot h \cdot m^{-3}$) and rounded to two significant digits (e.g., 0.4 $MBq \cdot h \cdot m^{-3}$ or 1.3 $MBq \cdot h \cdot m^{-3}$).

If gamma radiation measurements are performed, the results should be expressed as an ambient dose equivalent rate in micro-sieverts per hour ($\mu Sv \cdot h^{-1}$), rounded to one significant figure (e.g., 0.2 $\mu Sv \cdot h^{-1}$).

4.4 Comparison with the Reference Level

The radon concentration in each individual measurement point

should be compared with the reference level of 300 $Bq \cdot m^{-3}$. NRRC does not recommend averaging radon concentrations from multiple points for this comparison. The annual average radon concentration during working hours is determined by conducting a long-term measurement or using a combination of long-term and follow-up measurements (see Section 2.2).

If radon exposure exceeds the reference level, mitigation measures should be implemented, and the situation may need to be reported to NRRC, as shown in Figure 4.1.

Radon exposure is the product of radon concentration and the time spent in the workplace. This exposure is used to assess compliance with NRRC's occupational exposure limits and the reporting requirements of NRRC. It is important to note that for regulatory purposes, the comparison should be made using the estimated annual average radon concentration during working hours without adjusting for measurement uncertainty.

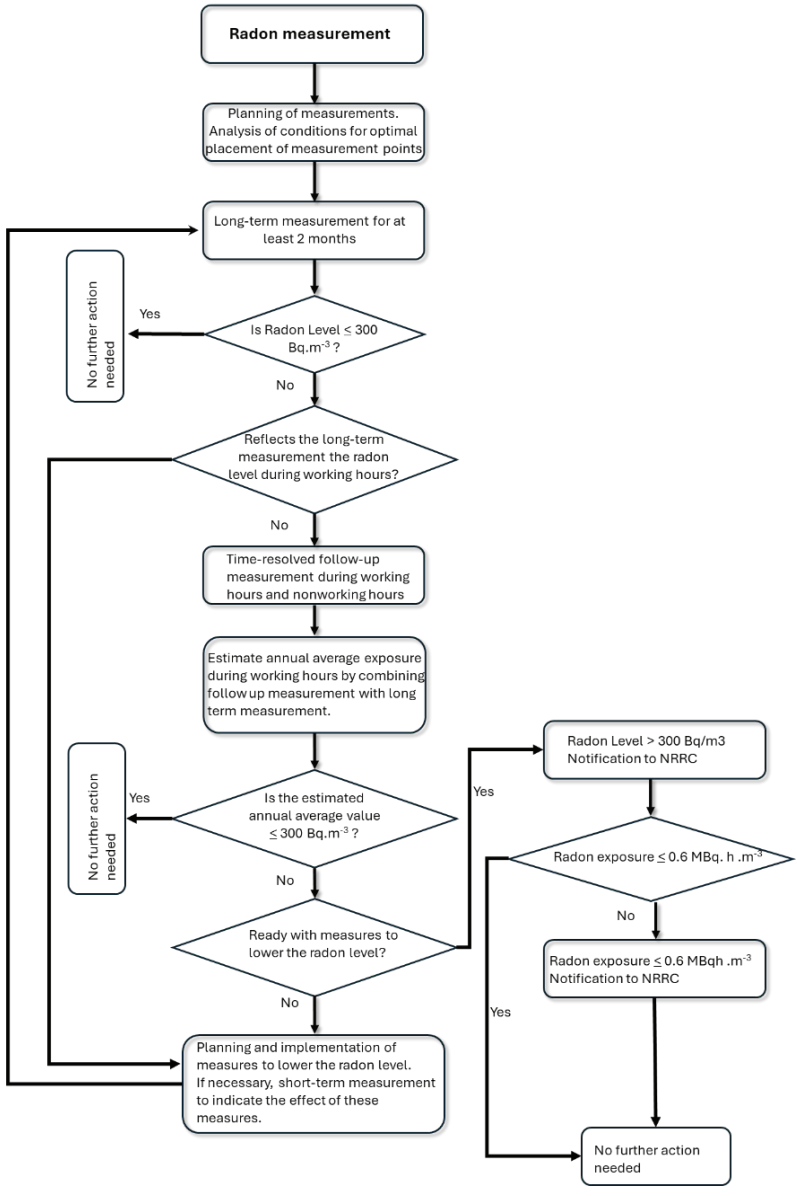

Figure 4.1: A flowchart explaining the actions needed for indoor radon measurement in public buildings

5. Protocol for Measuring Radon in Schools

The protocol for measuring radon in schools is focused on the environments where students or children spend some of their time. Radon measurements in schools and preschools should follow the methodology established for measuring radon in workplaces.

This protocol explains how to select school and preschool properties for radon measurement and outlines steps to be taken when radon levels exceed the national reference level. The reference level for indoor radon concentration is 300 Bq/m^3, which applies to public buildings, workplaces, and schools, as indicated by Table 1.1. By following the workplace radon measurement methodology, the results can be compared against this reference level.

5.1 Radon Measurement

Radon measurements should be conducted during regular school or preschool activities. Students or children should be present in the areas being measured, meaning measurements should not take place during holidays or school breaks.

Ventilation and heating systems should also be set to their usual settings. By measuring radon levels in spaces where students or children spend time, areas occupied by teachers and staff should also be measured.

If the goal is to assess radon levels in the environment of students

or children, measurements are not required in areas that students or children do not typically use. However, from an occupational health perspective, operators may request to measure additional areas used by staff. These extra measurements should be in addition to, not a replacement for, those done in student or child spaces.

In order to determine whether or not the levels of radon in schools and preschools are higher than the reference level, it is necessary to compare the yearly average radon level at each measurement location during occupied hours to the reference levels as described in the public building Section 4.4.

5.2 Selection of Measurement Location

When assessing radon levels in student or child environments, prioritize the areas where they spend the most time. Rooms that are only used for a few hours per week, such as cafeterias, art rooms, or gymnasiums, should not be a primary focus initially. These rooms can later be tested with short-term measurements to determine if long-term testing is necessary, especially if they are near elevator shafts, ventilation systems, or are located in basements with direct ground contact or contain some building materials known to emit radon.

The selected areas for long-term measurement should represent rooms that have not been measured. This means they should be

similarly used, belong to the same ventilation system, be on the same floor, or be in the same building.

When reporting results, ensure that the ventilation and heating systems are consistent with their usual daytime operation, even if measurements are taken during evenings or other non-standard hours.

If additional measurements are needed to evaluate the work environment for staff, the selection of rooms should follow the public buildings radon measurement protocol.

6. Related Documents and Files

Document Name	Document Type	Document No.	Relation to the Guideline
National Radon Reference Levels in Dwellings and Public Buildings	Specific Regulations	NRRC-R-01-SR10	Establishes the indoor air radon reference levels for dwellings and public buildings

AnnexI: Common Methods for Radon Measurements

The objective of this Annex is to provide information, recommendations, and technological guidance for anyone providing measurement services using radon and radon decay product measurement methods.

I.1 The protocol for the Electret Ion Chamber

This guideline presents equipment, procedures, and quality control to maintain consistent radon measurement practices. Equipment: Essential tools include the EIC detector, a surface voltmeter for voltage readings, and a log for data collection.

Method: EIC detectors contain a charged electret that collects ions produced by radon decay. The voltage reduction in the electret indicates the average radon concentration over the exposure period. Short-term and long-term detectors are available, and the measurement periods can range from 7 days to 12 months.

To ensure accurate and reproducible radon measurements using Electret Ion Chambers (EIC) and to help standardize measurement procedures across programs, the following recommendations should be met:

1. Pre-deployment Considerations: The deployment of the detector should account for the occupant's movements and be timed correctly to ensure accurate reading.
2. Measurement Criteria: It should cover various conditions for

accurate data, including the measurement period, which can provide radon data over an entire year.

3. Deployment and Retrieval: Selecting the location of measurement, timely deployment, and proper retrieval methods are provided to ensure reliable results.
4. Documentation: It's essential to document the detector's serial number, location, and room temperature changes.
5. Analysis Recommendations: Radon concentration analysis should consider the gamma radiation background. Sensitivity and precision details should be discussed, highlighting that 30% of errors are acceptable for short-term measures.
6. Quality Assurance: The program should include detector calibration, testing with known radon exposures, deploying duplicate detectors for precision testing, and monitoring for background gamma exposure and electret stability.
7. The document emphasizes calibration, duplicate testing, control detectors, and routine instrument checks to ensure accuracy.

I.2 The Protocol for Alpha Track Detectors

This guideline provides general recommendations on the equipment, procedures, and quality control needed for radon measurement but is not intended to replace instrument manuals. The main purpose of this protocol is to ensure accurate and reproducible radon measurements using Alpha Track Detectors

(AT), helping to standardize practices and enable comparison across measurement programs.

Equipment: AT detectors, instruction sheets, a log for data collection, and a sealed shipping container are required. Commercial suppliers often provide detectors along with analysis services.

Method: ATs consist of a plastic film enclosed in a container that allows radon to diffuse in, while alpha particles from radon decay leave damage tracks on the detector. After exposure, the detectors are processed in a lab where the tracks are counted. The number of tracks per unit area correlates with radon concentration, and the results reflect the average concentration over the exposure period.

To achieve the purpose of using this technique, the following recommendations should be met:

1. Pre-deployment Considerations: The detector should not be deployed if the occupant moves during the measurement period, and it should be installed as soon as possible after delivery to avoid background exposure.
2. Measurement Criteria: The document refers to a standard set of conditions for measurement. A 12-month AT/ATD measurement system can capture radon levels over the entire year without needing closed-building conditions.
3. Deployment and Retrieval: Detectors should be deployed immediately after delivery. After exposure, they should be

retrieved, resealed, and returned to the lab as soon as possible to avoid additional background exposure, which could skew the results.

4. Documentation: Standard documentation includes recording the deployment conditions, time of removal, and any changes noticed during retrieval.
5. Analysis Recommendations: The lower detection limit (MDA) for AT detectors is 35 $Bq \cdot m^{-3}$-month, and counting a larger area of the detector improves sensitivity and precision. Background tracks and net tracks should be carefully managed to maintain accurate results.
6. Quality Assurance: The quality assurance program involves calibration, known exposure tests (spiked detectors), duplicate detectors for precision testing, control detectors for background measurement, and routine instrument checks. Calibration is necessary once a year, and control detectors are essential to account for any background exposure during shipment or storage.
7. The protocol emphasizes proper calibration, duplication, and background control to ensure the accuracy of radon concentration measurements.

I.3 The Protocol for Continuous Radon Monitors

The following guide covers sample collection, analysis, equipment, and quality control for continuous radon monitor (CR)

measurements. It is intended as a guide and not a replacement for the instrument manual.

The protocol provides guidance for accurately measuring indoor radon levels using Continuous Radon Monitors (CR), ensuring uniformity and valid comparisons across programs. It emphasizes measurements under closed-building conditions for better reproducibility.

Method: The document describes three types of CR monitors:

- Scintillation Cell Monitors: Radon decay products generate scintillations in a chamber, detected by a photomultiplier.
- Ionization Chamber Monitors: Radon diffuses into the chamber, and alpha particles produce ions, which are counted as electrical pulses.
- Solid-State Silicon Detector Monitors: Ambient air diffuses into a chamber where alpha particles from radon decay are counted.

Equipment: The equipment varies by monitor type but includes the CR monitor itself, possibly a pump, and necessary calibration tools (e.g., aged air or nitrogen for background checks).

To achieve the purpose of using this technique, the following recommendations should be met:

1. Pre-deployment Considerations: The occupant's plans and the building's status should be considered before deployment. Pre-sampling checks include verifying the monitor's clock, timer, and pump operation.

2. Measurement Criteria: The document refers to standard conditions for accurate measurement, requiring at least 48 hours of monitoring, with longer times reducing uncertainty.
3. Deployment and Operation: CR monitors should run continuously for at least 48 hours, discarding initial data before conditions stabilize (typically the first four hours) for accurate reading.
4. Retrieval and Documentation: Upon terminating the measurement, the monitor's stop-time and the status of closed-building conditions should be documented, along with equipment serial numbers.
5. Analysis Recommendations:
    - Sensitivity: CR monitors typically have a lower detection limit of 35 $Bq \cdot m^{-3}$ or less.
    - Precision: CR monitors can achieve a precision variation of less than 15% at 200 $Bq \cdot m^{-3}$ or greater. Precision should be continuously monitored.
6. Quality Assurance: The quality assurance program includes:
    - Calibration: Monitors should be calibrated annually in a radon calibration chamber.
    - Background Measurements: After 1,000 hours of operation, background checks should be done using clean air or nitrogen.
    - Duplicate Measurements: Multiple CR monitors should be operated side by side for precision testing.

- Routine Instrument Checks: Radiation counting instruments should be checked regularly using a reference source, and flow meters should be routinely verified for accuracy.

The protocol emphasizes accurate calibration, consistent background checks, and routine equipment testing to ensure precise radon concentration measurements.

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