Radon Gas: Problems, Solutions and Guidance

CONTENT

List of Figures

SECTION 1: AN OVERVIEW OF RADON

1.1 Radon Background

Radon, referring to radionuclide (222Rn), is a gas that cannot be detected by human senses, as it is tasteless, colorless, and odorless. This radioactive gas occurs naturally through the decay of uranium, which is present in varying degrees in all soil and bedrock [1]. Since radon is a gas, it can easily move through soil and bedrock, where it can escape into outdoor air or infiltrate homes or buildings. Once radon is released from the ground, it quickly dilutes and is no longer a significant health hazard in the outdoor air.

The air pressure inside a building is usually lower than the pressure outside and in the soil, particularly in the lower foundation levels, which can cause the building to act like a vacuum and draw in soil gases, including radon, through any openings. Common entry points for radon gas include gaps around service pipes, construction joints, cracks in foundation walls, and floor slabs, among others. High concentrations of radon gas can accumulate in indoor air and pose a health risk to the occupants [1]. In addition, water supply can be another source of radon infiltration in buildings or homes. Radon may dissolve and accumulate in groundwater affecting regions that rely on private or community wells.

Research has indicated that inhaling radon gas increases the risk of lung cancer, which is significantly higher than the risk of stomach cancer from ingesting water with high radon levels. However, when water containing high levels of radon is agitated during activities such as showering, washing clothes, or cooking, the gas can be released into the indoor air, which can pose a health risk to occupants. Therefore, the health risks associated with radon dissolved in water are from the inhalation of air that contains radon gas that has been released, not from ingestion.

Regardless of the age, type of construction or location of the home/building, the only way to accurately quantify indoor radon levels is to conduct testing after occupancy.

1.2 Health Hazards of Radon

The International Agency for Research on Cancer (IARC) has categorized radon as a Category 1 Carcinogen, which means that it is a definite cause of cancer in humans, along with other substances such as asbestos, arsenic, and benzene [2].

An individual's risk of developing lung cancer depends on a few factors:

- The average radon concentration in the building
- The duration of time the individual is exposed
- The individual's status as a smoker or non-smoker

As radon gas is inhaled, it breaks down to form radioactive particles that can get lodged in lung tissue. Radon decays and emits alpha particle radiation which can damage the DNA in lung tissue. Cancer occurs when genetic mutations impact how a cell grows, divides and/or spreads. When more genetic mutations accumulate over time, the risk of a cell becoming cancerous increases [2]. Not everyone exposed to radon will develop lung cancer, and the time between exposure and the onset of disease can take many years [1].

Health Canada estimates that a non-smoker exposed to elevated levels of radon has a 1 in 20 chance of developing lung cancer over their lifetime. The deadly combination of smoking tobacco while being exposed to the same level of radon significantly increases the risk of lung cancer to a 1 in 3 chance over the individual's lifetime [1]. Radon is the second-leading cause of lung cancer after smoking, and the primary cause of lung cancer among non-smokers [3]. Health Canada estimates the annual death rate in Canada from exposure to radon-induced lung cancer is 3,200 deaths – which is higher than the annual deaths for car accidents (1,889), carbon monoxide poisoning (300) and house fires (108) combined [4].

The risk of lung cancer from radon gas exposure is significant but preventable. The only way to know if you are at risk of radon exposure is to test radon levels. If high levels are found, action must be taken to reduce those levels.

1.3 Radon in Canada

In 1988, Health Canada established a national guideline for safe indoor air radon levels at 800 Bq/m^3, which remained unchanged until 2007. Health Canada updated the guideline in response to new scientific information and aligned it with international standards, bringing it down to 200 Bq/m^3. The World Health Organization (WHO) recommends a national reference level of 100 Bq/m^3, and U.S. agencies suggest a level of ~148 Bq/m^3 (4 pCi/L).

The current guidelines in Canada require remedial action to be taken to ensure the average indoor radon concentration does not exceed 200 Bq/m^3. The higher the radon concentration, the sooner remedial measures should be taken. It is recommended to take action within one year for average radon concentrations exceeding 600 Bq/m^3.

Although there are no radon-free areas in Canada, some regions have higher levels of indoor radon concentrations than others, as illustrated in Figure 1 of the radon potential map for Canada. Several factors, such as soil characteristics, construction type, foundation condition, occupant lifestyle, and weather, affect the amount of radon in a home or building. The use of radon potential maps is not a reliable indicator of an individual building's chance of having elevated radon levels, as neighboring buildings can have varying radon concentrations despite being similar construction types.

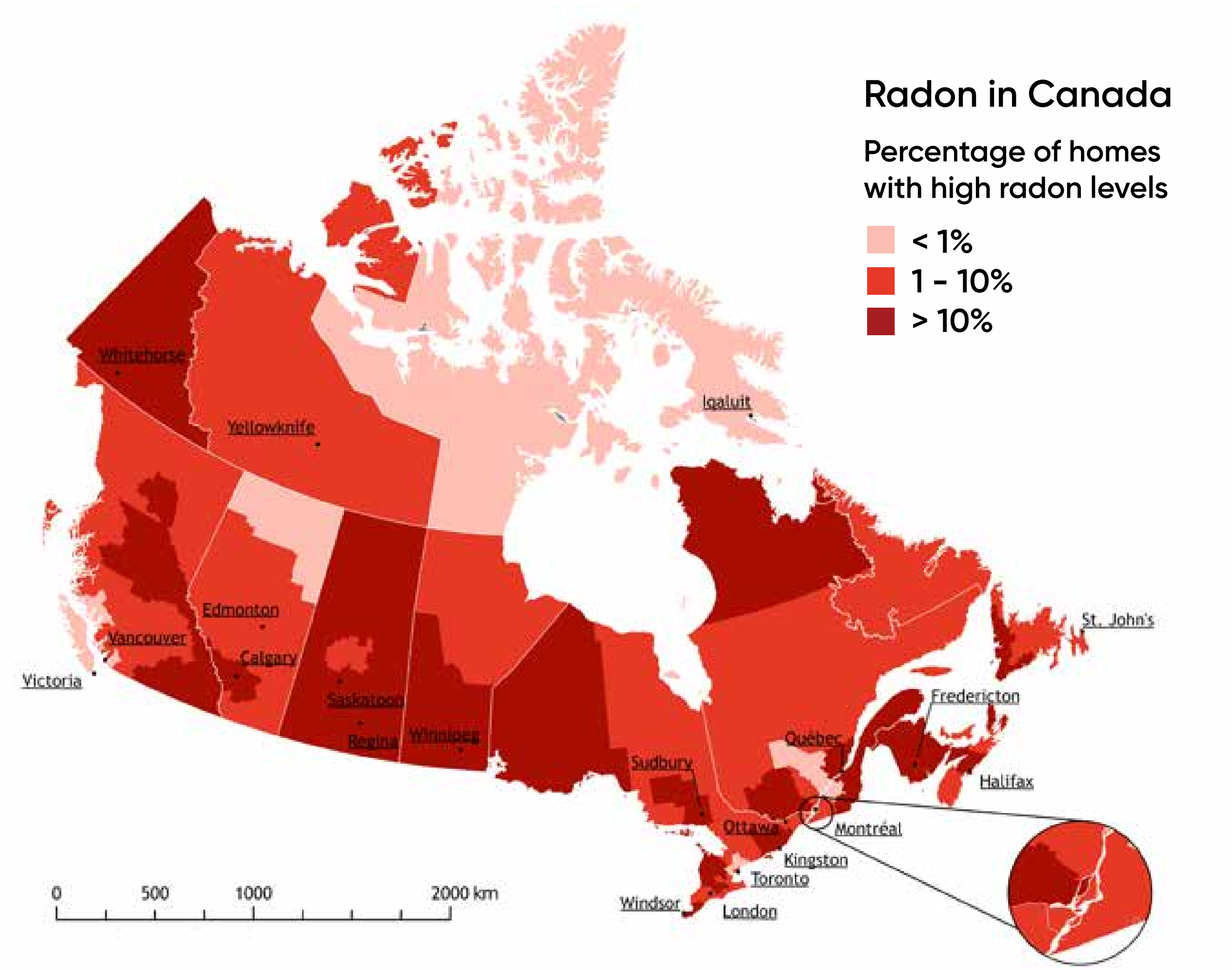

Figure 1 - Radon potential map for Canada provided by Health Canada, in collaboration with data obtained from the Cross-Canada Radon Survey (2011) and Radon Thoron Survey (2013) [5].

1.4 Measuring Radon Levels

The quantity of radon in a home or building is affected by various external factors, such as soil characteristics, construction type, foundation condition, and weather. Moreover, occupant lifestyle can also impact radon levels. The use of exhaust fans, opening or closing windows, and the use of fireplaces can alter the pressure difference between the building and the soil, which affects the rate of exchange of indoor and outdoor air. Radon concentrations can vary hourly, daily, and seasonally. As a result, radon measurements taken over an extended period, primarily during winter months where the stack effect is largest, provide a more accurate representation of radon concentration levels. Figure 2 demonstrates this variability, displaying peaks of radon concentration levels as high as 2950 Bq/m^3 and valleys as low as 50 Bq/m^3, with an average of roughly 1300 Bq/m^3 over a three-week period. If a homeowner conducted a short-term test during a time of low radon levels, they could wrongly believe their home was within the national guideline.

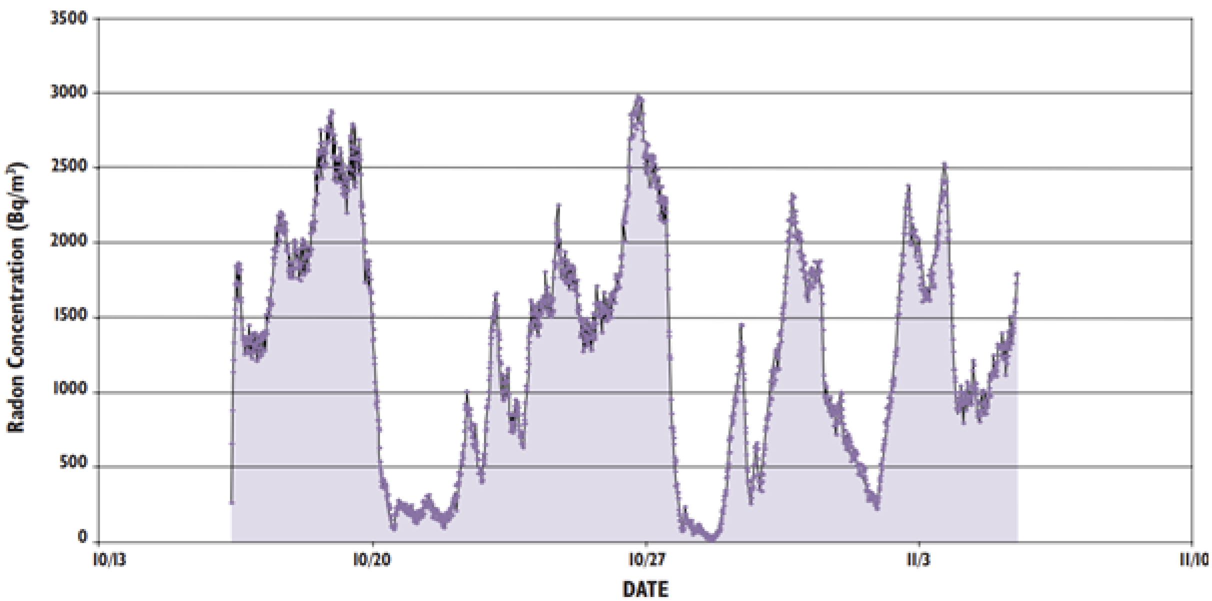

Figure 2 - Example of Radon Concentration Variability During a Test [6].

Health Canada recommends conducting a long-term radon test for a minimum of three (3) months to obtain an accurate representation of the radon concentration levels in a home or building. The testing period should ideally cover the heating season, from October to April, when the thermal stack effect is strongest, and more radon gas is drawn into the dwelling from the soil [1]. This period typically corresponds to the time when indoor radon levels are highest in Canada. The average radon concentration obtained during this period can be used as a benchmark to determine if the home or building exceeds the Canadian guideline level of 200 Bq/m^3, which represents a person's annual average exposure. Do-it-yourself radon test kits are available for purchase from various retail channels and come with instructions for optimal test location and submission for analysis. If radon levels exceed the Canadian guideline, Health Canada recommends hiring a professional certified under the Canadian National Radon Proficiency Program (C-NRPP), and a list of certified professionals can be found on www.c-nrpp.ca.

SECTION 2: RADON MITIGATION TECHNIQUES

2.1 How Does Radon Enter a Home?

Radon is a naturally occurring radioactive gas that emanates from the ground, easily moving through soil and bedrock, and potentially entering and reaching dangerous levels in homes and buildings. The radon concentration in a region depends on the concentration of uranium and/or radium in the soil underneath; radon is produced by the natural decay of these elements. However, a home or building may be built on radon enriched soil and yet still have low radon concentrations present in the indoor air. Soil gases, including radon, are drawn into a home or building by a difference in air pressure – essentially turning the dwelling into a vacuum. Yet, with this driving force present, there is still a requirement of potential entryways for the soil gases to travel through. Drains, cracks in the foundation wall and slab, gaps around pipes, and other openings provide points of entry for the soil gases. Energy-efficiency practices which make a building more air-tight (e.g., sealing around windows and doors) reduce passive ventilation and can lead to higher indoor radon concentrations unless complementary radon-reduction strategies are in place [7]. A combination of radon enriched soil, entryways into the home or building and reduced passive ventilation without radon-reduction strategies is a recipe for elevated radon levels within the occupied spaces.

2.2 Principles of Reducing Radon Entry and Mitigation Methods

Radon concentrations in indoor air can be reduced by impeding the flow of soil gases to areas in contact with the home or building. The flow of soil gases can be reduced by:

(1) Eliminating all openings to the soil through the foundation, completely sealing all contact points of the home or building with the soil, and

(2) Reducing the pressure difference between the soil beneath the home or building so that soil gases do not enter the interior

Attempting to seal all the openings in the foundations of home or building is both impractical and ineffective as a standalone method to reduce radon gas, and other soil gases, from penetrating through. Since it is a gaseous substance, radon can enter through the most minuscule cracks. Even though most cracks may be sealed during the construction of the home or building, over time building settlement may cause new cracks to appear and provide entry ways for radon ingress. There are several different mitigation methods that can be employed to address high radon concentrations in indoor air. These may vary for different foundation types, access to the foundation, as well as underlying costs associated with installation and operation of the system.

The benchmark mitigation method that is the most effective, reliable, and cost conscious is a technique known as sub-slab depressurization. Simply put, this method involves having a pipe inserted into the sub-slab fill to vent the soil gases found beneath the foundation of the home or building. The gravel beneath the concrete slab, the gas-permeable layer, plastic sheeting, and sealing/caulking are methods already employed in building codes to address moisture reduction in the home or building. As a stand-alone method, sealing the foundation rarely reduces the indoor radon concentrations below the acceptable guidelines. It is difficult to seal all access points for radon and other soil gases [8]. Although sealing the foundation opening is an ineffective stand-alone method as a radon resistance feature, it is a supportive first step for radon mitigation. In addition to sealing all the openings in the

foundation, routing a vent pipe from the gas-permeable layer and conditioned space, terminating through the roof line will produce a natural draft in the pipe due to the stack effect. This method will safely vent radon and other soil gases before they infiltrate the occupied spaces. Preventive measures taken at the time of construction are more practical and economically viable, while significantly reducing high radon concentrations in indoor air before becoming problematic.

In new construction, there are three different levels of sub-slab depressurization methods that can be installed:

Level-1: Rough-in:

- In a Level-1 system, a capped rough-in stub is installed, with an access point to the gas permeable layer. This method is not a complete radon reduction system, it is only a rough-in, and forms the basis for either a Level 2 (passive) or Level 3 (active) radon mitigation system.

Level-2: Full Passive Stack:

- In a Level-2 system, the capped rough-in pipe is replaced by a full vertical pipe stack that extends through the home vertically and terminates above the roof. In a majority of cases, this level of radon mitigation is sufficient to lower the radon concentrations within the home or building to acceptable limits.
- If radon levels are still above Health Canada's recommended concentrations with a passive stack, further reductions can be made by installing a radon fan (Level 3).

Level 3: Active Stack

- A Level-3 system supplements a Level-2 option of a passive stack by installing a radon fan that is activated to generate a pressure difference which draws radon gas from the sub-slab region to safely vent outdoors. Active soil depressurization systems are the most effective choice for reducing high radon levels in indoor air.
- This system can be terminated either above the roof line or on a side-wall due to the fan being the driving force for the pressure difference between the sub-slab region and the home or building.
- This level of radon mitigation is the primary installation method for retrofit applications in existing homes or buildings.

In existing construction, it is not practical to install a complete radon mitigation venting system, that includes a sub-slab pipe and/or a full vertical stack after occupancy – especially if the lower levels of the building are finished. Therefore, a majority of the retrofit applications for soil gas venting are a Level-3: Active Stack, with termination on a side wall. In addition, a 'pressure field extension test' (e.g. communication test) should be performed to determine the number of suction points, location of suction points and the fan size needed for an effective system. It is recommended, that all retrofit installations for existing homes should be carried out by a professional who is certified under the Canadian National Radon Proficiency Program (C-NRPP).

In all cases, homes, or buildings with any radon mitigation provisions in place should still have the radon levels tested to ensure the chosen mitigation approach sufficiently reduces radon levels below Health Canada's acceptable levels.

SECTION 3: RADON IN THE BUILDING CODE

3.1 Current State of the Building Code

There is no definite way to determine, before construction, if a home or building will have high radon levels indoors. Soil testing can be conducted prior to construction, but it does not rule out the possibility that radon will be a problem in the home or building on the lot. Soil testing should not be used as a precursor to build a radon resistant home. Even if testing reveals low levels of radon gas in the soil, there is no reliable method to predict the levels of radon gas in the constructed home or building.

Radon mitigation provisions implemented in new construction are an economically feasible and effective approach to address growing concerns of the health effects associated with long-term exposure to high radon levels. The 2015 National Building Code Section 9.13.4.2, as well as the 2020 version, mandates a Level-1: Rough-in for an active soil depressurization system as the minimum preventative measure for radon control in all new construction homes built in regions that adhere to this building code. However, all new homes or buildings are not subjected to mandatory post-occupancy testing. This approach is the bare minimum to address radon levels in a home or building. The excerpt from the 2015 National Building Code pertaining to Soil Gas Control is in Appendix A.

Health Canada recommends that all provinces and territories incorporate radon reduction into their building codes [1]. Many provinces have adopted the 2015 National Building Code – which does specify a rough-in installation. However, this does not reduce radon levels in the home, instead it can be used as a connection point for either a Level 2 (passive) or Level 3 (active) radon mitigation system.

3.2 Municipality Approach

In some provinces, municipalities have the authority to decide whether radon provisions apply in their area or if they can add radon provisions to building codes. The degree to which a local government can enforce more stringent building regulations is determined by the legal framework at both the provincial and municipal levels. In Ontario, several municipalities have implemented stricter standards for radon provisions, including Guelph, Hamilton, Niagara, Kingston, and a few others. Municipalities can also incorporate radon provisions into construction approval processes, such as building permits, and enact property standards bylaws that protect renters, which may include radon regulations. Additionally, municipalities can launch their own community testing or incentive programs for radon testing and mitigation.

At the end of 2014, British Columbia introduced new requirements for protection against soil gases in the BC Building Code. Prior to the new requirements, there were provisions in place that mandated the capping of the radon rough-in pipe inside the building. However, this approach did not effectively reduce indoor soil gas concentrations, and stakeholders expressed concerns about the suitability of the rough-in's location and condition for future connection to a radon mitigation system [9].

Under the new provisions, new buildings in specific geographic regions outlined in Table C-3 of the British Columbia Building Code 2018 are now required to have a Level-2: Passive Stack radon mitigation system installed. Figure 3 illustrates the geographical separation of radon regions in British Columbia. Radon Area 1 refers to locations that have demonstrated an elevated risk of exceeding

Canada's national guideline of 200 Bq/m^3 for indoor radon levels. The installation involves adding a radon vent pipe to the existing rough-in, which extends through the building and terminates outside [9]. These changes apply to Part 9 dwelling units and buildings with residential occupancies. However, it is still the responsibility of the owner to test their home, and it is recommended to conduct radon testing after the installation of a radon mitigation system for validation.

Most provinces have implemented radon protection measures for new construction, but the degree of radon mitigation varies. Some provinces only require the bare minimum Level-1: Rough-in as specified in the 2015 National Building Code, while British Columbia mandates Level-2: Passive Stacks in radon-prone areas. It is the responsibility of the municipalities to enforce the building code, which plays a crucial role and should be carried out with the necessary standard of care. Building inspectors should also receive adequate training on radon and radon mitigation systems

Figure 3 - Geographical separation of Radon Areas 1 and 2 in British Columbia, Canada [9]

3.3 Leading by Example – City of Guelph Overview

A leading example of a municipality that has a radon mitigation program as a best practice for building code provisions is the City of Guelph in Ontario. This municipality is proactively addressing radon gas in new buildings and additions through their Radon Gas Mitigation Program [9]. In contrast, the Ontario Building Code identifies a minor number of areas that require buildings to be designed and constructed to ensure the average radon concentration in indoor air remains below 200 Bq/m^3 – in which Guelph does not reside in.

Guelph's Radon Gas Mitigation Program applies to all building permits applied for after August 31, 2015 – with the program's primary goals to accomplish the following:

(1) Create an effective radon gas mitigation program,

(2) Proactively address potential exposure to radon gas, and

(3) Reduce potential health risks to building occupants.

Under this radon mitigation program, all new low-rise residential buildings will need to have one of three options to limit the exposure of occupants to radon gas. One of the following mitigation methods is required before a permit is issued:

1. Rough-in soil gas pipe and mandatory radon gas testing.
2. Soil gas barrier on the foundation walls, soil gas barrier under the basement floor slab, and
3. Soil gas barrier on the foundation walls, active sub-slab depressurization system.

Depending on the option that the builder adopts, the home will be subject to either voluntary or mandatory radon testing – with all radon gas testing being long-term (min. 91 days) and completed by a C-NRPP certified professional.

The Radon Gas Mitigation Program also extends to all new industrial, commercial, and institutional (ICI) buildings, in which they must be designed and constructed in accordance with requirements in the Ontario Building Code. These requirements include:

1. Sealing of walls (e.g. bituminous dampproofing), roofs (e.g. suitable waterproofing membrane) and floors (e.g. 6 mil polyethylene sheet) that are in contact with the soil, including connections and any penetrations through them,
2. Pipe rough-in only of an active soil depressurization system,
3. Mandatory long-term testing (min. 91 days during winter months), and
4. Installation of a full active soil depressurization system if concentration levels measured by long-term testing exceed 200 Bq/m^3.

There are a few exemptions to the required radon gas requirements for different building application and types which include: additions that do not exceed 50m^2 in building area, parking garages, storage buildings, temporary structures (e.g. tents), and unenclosed buildings or additions (e.g. pavilions, bleachers etc.).

The City of Guelph is one of several Ontario municipalities that have moved forward with more robust radon mitigation requirements in their jurisdictions, requiring buildings to incorporate radon prevention measures from the outset in all new home and building constructions. Since the inception of Guelph's Radon Mitigation program, neighboring municipalities have followed the same path, with the City of Hamilton and the Niagara Region adopting similar requirements for radon mitigation. We can learn from these municipal initiatives on radon mitigation and adapt the requirements as new scientific findings emerge over time.

3.4 Home Warranty Programs

The air pressure differences between a home or building and the soil surrounding the foundation is a driving force for soil gases, including radon, to infiltrate occupied spaces. With this pressure differential present, radon gas still requires pathways to enter. These pathways can be foundation flaws, areas around penetrations, floor to wall joints etc. Tarion, a home warranty provider in Ontario, treats high radon as a major structural defect and explicitly warrants construction against levels of radon exceeding 200 Bq/m^3 for seven years upon construction completion. The burden then lies on the homeowner to either buy a do-it-yourself radon test kit or hire a radon measurement or mitigation professional to carry out the readings. Both options must be certified through the C-NRPP to be eligible for coverage under the new home warranty program. Although there may be radon provisions in the current version of the building code – the extent of radon mitigation referenced may fall short of reducing levels below Health Canada's guideline. A common myth is the notion that newer homes are less susceptible to high radon levels in comparison to older homes. While new homes are built to be energy efficient and air-tight, they can also harbor high radon levels. A recent study has shown that radon levels in new Canadian homes are now 467% higher in comparison to homes in Sweden [10]. All homes or buildings should be tested whether they are old or new – it is imperative to actively know your radon levels to ensure a healthy occupied space.

SECTION 4: SOIL GAS VENTING SYSTEM

4.1 Current Products Used for Radon Mitigation

There are currently no application-specific product performance standards to address radon mitigation in Canada. Radon mitigation is a life-safety application that can have severe consequences if inadequate products are used. Acrylonitrile butadiene styrene (ABS), sewer pipe, and other polyvinyl chloride (PVC) drain-waste-vent (DWV) plumbing products of different colors have historically been used for radon mitigation. With no radon specific system (sub-slab depressurization) available in the market – radon mitigators installed what was available to them with a cost-conscious mindset. These products have not been tested for this application and mitigators are inheriting a risk by installing them. In many instances, the products used for rough-in stubs have been misidentified as a DWV connection in basements due to a lack of labeling and identification.

The Canadian General Standard Board's (CGSB-2019), "Radon control options for new construction in low-rise residential buildings", is a recognized mitigation standard in Canada – this standard provides detailed technical prescription for radon mitigation strategies. However, this standard serves as a guideline for mitigators and is not a performance standard to evaluate the products being used. There is an active 'Committee on Radon Mitigation', comprised of diverse professionals in the industry that are striving to bolster the standard to submit to the National Building Code committee for implementation in the next version of the building code. To differentiate radon venting systems in a home or building, the standard suggests a different colored pipe be used, with clear and concise radon specific labeling on pipes and fittings.

4.2 RadonX™ Soil Gas Venting System from IPEX

RadonX™ by IPEX, is the first engineered PVC piping solution that is specifically designed, tested and labeled to address the need for collecting and venting soil gas, including radon, from the sub-slab area to help reduce indoor radon levels. The RadonX product offering consists of a grey PVC gas collection (perforated) and vent (non-perforated) pipes, fittings, solvent cement, and termination accessories. The physical dimensions and tolerances of RadonX pipe and fittings comply with CSA B181.2 and satisfy the requirements of the 2015 National Building Code Section 9.13.4 Soil Gas Ingress.

While there is presently no dedicated piping standard for the application of soil gas venting, RadonX is tested to and complies with the recognized standards outlined in Figure 4.

Description	Standards	RadonX™
Tolerances and dimensions	CSA B181.2; ASTM D2665	✓
All material and testing requirements	CSA B181.2; ASTM D2665	✓
Gas venting system performance tests (1) Gas leakage, (2) Pull-out. (3) Torque, (4) Combustibility	ULC S636	✓
Solvent cement	ASTM D2564	✓
Product markings	CGSB/CAN 149.11 CGSB/CAN 149.12	✓
Flame Spread Rating not exceeding 25	CAN/ULC S102.2	✓

Figure 4 - RadonX Soil Gas Venting system compliance to standards.

Moreover, the effectiveness of RadonX gas collection pipe has been compared with other commonly used piping products through field studies carried out by the National Research Council of Canada. The evaluated piping products include open-ended Sch.40 pipe, perforated BDS sewer pipe, and ABS pipe. To install active and passive piping stacks, a one-story test house with a basement was utilized. The findings indicated that regardless of the type of depressurization system utilized (active or passive), the RadonX gas collection pipe buried within the gravel layer produced the highest airflow in the vent and the greatest depressurization in the sub-slab area. This implies that the RadonX soil gas piping system can remove more soil gas from the sub-slab region. During the one-month testing period, a passive RadonX soil gas venting system was installed as initial radon levels exceeded 264 Bq/m^3. As a result, the radon levels were decreased by 93% to 17.9 Bq/m^3.

The RadonX soil gas venting system is characterized by a unique feature, namely the patent pending RadonX rain cap, which was employed during the experiment on the one-story dwelling. The test findings revealed that the RadonX rain cap had greater airflow in vent stacks when matched against the standard mesh type termination with identical piping arrangements. What is even more noteworthy is that the experiment was conducted in a winter month, and it was observed that the opening of the RadonX rain cap did not become obstructed by condensation and ice accumulation.

4.3 Engineering Specifications

Engineers prefer a specifiable product system because it offers them a pre-engineered solution that meets specific requirements for a particular application. Such a system can save engineers valuable time and effort during the design process by providing pre-tested and pre-engineered components that meet code requirements, ensuring that the system is installed and functions correctly. It also allows engineers to exercise greater control over the quality of the products they specify, reducing the risk of choosing products that may not be compatible with the overall system. In the case of radon mitigation, a specifiable product system like RadonX presents several advantages.

First, RadonX is a complete system that is purpose-built to address radon gas issues in buildings, making it a more effective solution than a piece-meal approach, which may not provide comprehensive coverage. Second, RadonX is code compliant, meeting the minimum requirements of the building code for radon mitigation. This is an essential factor for design engineers, who must ensure that their designs comply with all relevant regulations and codes. Third, RadonX has been evaluated for performance through third-party testing against available alternatives, and the results have demonstrated its effectiveness and reliability. This gives design engineers confidence in the product's performance, which is crucial when specifying products for their projects.

By highlighting the attractiveness of the RadonX product line as a complete system, design engineers can confidently specify a reliable and effective solution for their radon mitigation projects. Overall, a specifiable product system eliminates the need for engineers to spend time sourcing individual components and testing them individually, ultimately saving them time and effort in the design process. A technical specification summary of the RadonX system is shown in Appendix B.

4.3 RadonX Case Studies

Radon mitigation is recommended for all types of buildings in Canada, including commercial buildings. Many Canadian provinces have building codes that require radon-resistant construction measures for new construction, such as installing a passive radon mitigation system. These measures aim to prevent the entry of radon gas from the ground into buildings and to facilitate the installation of an active radon mitigation system if necessary.

If a building is already constructed and has not been designed to be radon-resistant, it is important to test for radon levels regularly. If high levels of radon are detected, then proper radon mitigation measures should be implemented to reduce the concentration of radon gas to safe levels. This may include installing an active radon mitigation system, which involves the installation of a ventilation system to remove radon gas from the building.

The RadonX Soil Gas Venting system has been employed in diverse settings, including long-term care facilities, residential developments, schools, and other commercial buildings, among others. The following sections present some noteworthy projects that have made use of RadonX to conform to building codes and reduce radon levels, creating a safer environment for occupants.

4.3.1 Long-Term Care Facility in Meteghan

Since 1975, Villa Acadienne has provided care for residents in Digby County, Nova Scotia, starting with 45 beds and growing to 86 to meet demand. Despite continuous improvements, a decision was made to replace the original building in the same community with a new facility featuring 96 beds. According to a Saltwire article, this new building is one of the first long-term care facilities to be built in compliance with the new Department of Health and Wellness standards. To enhance resident safety, M&R Engineering opted to include the IPEX RadonX soil gas venting system in the Villa Acadienne project. This system expels radon gas from beneath the building's foundation and reduces the risk of radon gas seeping into the facility.

4.3.2 Radon Safety at the Beach

Marz's new town home development, called "The Shores," is situated in Crystal Beach, near Fort Erie, Ontario. It is an extension of an ongoing development near the shore, providing 48 new one and two-story town homes. With the awareness of the potential dangers posed by radon and the introduction of municipal by-laws making radon mitigation mandatory in new constructions, Marz has taken the initiative to make all new town homes 'radon-ready.' In Crystal Beach, a certified radon mitigation contractor was employed to install comprehensive systems that vent radon gas from the sub-slab area of the town homes, giving homeowners peace of mind that their homes are equipped with a radon mitigation system that could save lives.

4.3.3 Mountain View Heights Moves to "Radon Ready" with IPEX

The Greenpark Group's Mountain View Heights development, situated in the Niagara escarpment, has taken proactive measures to ensure that the homes constructed within the project are prepared for potential radon gas issues. Hamilton, Ontario, and other municipalities have established guidelines for new low-rise construction by mandating rough-in installation for future radon mitigation if test results indicate elevated levels beyond national standards. The RadonX soil gas venting system, developed by IPEX, was used in this project for the rough-in installation. A portion of perforated gas collection pipe was installed in the gravel base beneath the concrete sub-slab in the basement, which was then connected to a vertical solid pipe passing through the floor. The solid pipe was capped pending the results of radon level testing. In the event of elevated radon levels post-occupancy, the solid vent pipe could be vented either through a basement sidewall or through the roof of the house, provided an available route. All components of the RadonX system are clearly labeled to distinguish them from other commonly used plumbing products, ensuring that the life-safety system remains untampered.

SECTION 5: ADDITIONAL RESOURCES

The following sources can provide more information on radon in homes:

- **Canadian Cancer Society** (www.cancer.ca)
- **Health Canada** - Radiation Health Assessment Division (www.canada.ca)
- **Canadian Lung Association** (www.lung.ca/radon)
- **Canadian Associations of Radon Scientists and Technologists, CARST** (www.carst.ca)
- **IPEX Inc.** (www.ipexna.com)

References

[1.] H. Canada, “Health Canada Guide for Radon Measurements in Residential Dwellings (Homes),” 24 August 2021. [Online]. Available: https://www.canada.ca/en/health-canada/services/publications/health-risks-safety/guide-radon-measurements-residential-dwellings.html.

[2.] E. Radon, “Radon and cancer-causing mutations,” 2022. [Online]. Available: https://evictradon.org/radon-and-cancer-causing-mutations/.

[3.] L. Gue, “Revisiting Canada’s Radon Guideline,” David Suziki Foundation, p. 24, April 2015.

[4.] G. o. Canada, “Radon gas: it’s in your home,” 07 11 2017. [Online]. Available: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/radiation/radon-your-home-health-canada-2009.html. [Accessed 08 10 2022].

[5.] G. o. Canada, “Data Blog,” 21 11 2019. [Online]. Available: https://health-infobase.canada.ca/datalab/radon-blog.html. [Accessed 08 10 2021].

[6.] H. Canada, “Reducing Radon Levels in Existing Homes: A Canadian Guide for Professional Contractors,” p. 70, 2010.

[7.] J. M. e. al., “Home Energy Efficiency and Radon Related Risk of Lung Cancer: Modelling Study,” British Medical Journal , no. 348, 2014.

[8.] G. o. Canada, “Radon action guide for municipalities: Duties, policies, bylaws and incentives,” Government of Canada, 13 10 2022. [Online]. Available: https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radon/action-guides/municipalities/duties-policies-bylaws-incentives.html. [Accessed 15 11 2022].

[9.] B. a. S. S. Branch, “Information Bulletin - New Radon Rough-in Requirements,” British Columbia, 19 September 2014. [Online]. Available: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/b14-07_new_radon_rough-in_requirements.pdf. [Accessed 10 May 2023].

[10.] “Radon Gas Mitigation Program,” [Online]. Available: https://guelph.ca/city-hall/building-permits-inspections/residential-building-permits/radon/#:~:text=Canada’s%20radon%20guideline%20is%20200,metre%20(Bq%2Fm3).. [Accessed 10 11 2022].

[11.] D. D. P. T. R. M. E. N. J. M. T. &. A. A. G. Selim M. Khan, “Rising Canadian and falling Swedish radon gas exposure as a consequence of 20th to 21st century residential build practices,” Scientific Reports, p. 15, 2021.

APPENDIX A:
NATIONAL BUILDING CODE EXCERPTS PERTAINING TO SOIL GAS INGRESS

2015 National Building Code, Part 9 - Housing and Small Buildings

9.13.4 Soil Gas Control

(See Note A-9.13.4.)

9.13.4.1. Application and Scope

1) This Subsection applies to

a) wall, roof, and floor assemblies separating conditioned space from the ground, and

b) the rough-in to allow the future protection of conditioned space that is separated from the ground by a wall, roof, or floor assembly.

2) This Subsection addresses the leakage of soil gas from the ground into the building.

9.13.4.2. Protection from Soil Gas Ingress

1) All wall, roof and floor assemblies separating conditioned space from the ground shall be protected by an air barrier system conforming to Subsection 9.25.3.

2) Unless the space between the air barrier system and the ground is designed to be accessible for the future installation of a subfloor depressurization system, dwelling units and buildings containing residential occupancies shall be provided with the rough-in for a radon extraction system conforming to Article 9.13.4.3.

3) Where buildings are used for occupancies other than those described in Sentence (2), protection from radon ingress and the means to address high radon concentrations in the future shall conform to

a) Article 9.13.4.3., or

b) Parts 5 and 6 (see Article 5.4.1.1. and 6.2.1.1.).

(See Note A-9.13.4.2.(3).)

9.13.4.3. Providing for the Rough-in for a Subfloor Depressurization System

(See Note A-9.13.4.3.)

1) Floors-on-ground shall be provided with a rough-in for subfloor depressurization consisting of

- a) a gas-permeable layer, an inlet, and an outlet as described in Sentence (2), or
- b) clean granular material and a pipe as described in Sentence (3).

2) The rough-in referred to in Clause (1)(a) shall include

- a) a gas-permeable layer installed in the space between the air barrier and the ground to allow the depressurization of that space,
- b) an inlet that allows for the effective depressurization of the gas-permeable layer (see Note A-9.13.4.3.(2)(b) and (3)(b)(i)), and
- c) an outlet in the conditioned space that
  - i) permits connection to depressurization equipment,
  - ii) is sealed to maintain the integrity of the air barrier system, and
  - iii) is clearly labeled to indicate that it is intended only for the removal of radon from below the floor-on-ground.

3) The rough-in referred to in Clause (1)(b) shall include

- a) clean granular material installed below the floor-on-ground in accordance with Sentence 9.16.2.1.(1), and
- b) a pipe not less than 100 mm in diameter installed through the floor, such that
  - i) its bottom end opens into the granular layer required Clause (a) at or near the centre of the floor and not less than 100 mm of granular material projects beyond the terminus of the pipe measured along its axis (see Note A-9.13.4.3.(2)(b) and (3)(b)(i)),
  - ii) its top end permits connection to depressurization equipment and is provided with an airtight cap, and
  - iii) the pipe is clearly labeled near the cap and, if applicable, every 1.8 m and at every change in direction to indicate that it is intended only for the removal of radon from below the floor-on-ground.

Notes to Part 9: Housing and Small Buildings

A-9.13.4. Soil Gas Control. Outdoor air entering a dwelling through above-grade leaks in the building envelope normally improves the indoor air quality in the dwelling by reducing the concentrations of pollutants and water vapour. It is only undesirable because it cannot be controlled. On the other hand, air entering a dwelling through below-grade leaks in the envelope may increase the water vapour content of the indoor air and may also bring in a number of pollutants picked up from the soil. This mixture of air, water vapour and pollutants is sometimes referred to as "soil gas." One pollutant often found in soil gas is radon.

Sentence 9.13.4.2.(1), which requires the installation of an air barrier system, addresses the protection from all soil gases, while the remainder of Article 9.13.4.2. along with Article 9.13.4.3., which require the provision of the means to depressurize the space between the air barrier and the ground, specifically address the capability to mitigate high radon concentrations in the future, should this become necessary.

Radon is a colourless, odourless, radioactive gas that occurs naturally as a result of the decay of radium. It is found to varying degrees as a component of soil gas in all regions of Canada and is known to enter dwelling units by infiltration into basements and crawl spaces. The presence of radon in sufficient quantity can lead to an increased risk of lung cancer.

The potential for high levels of radon infiltration is very difficult to evaluate prior to construction and thus a radon problem may only become apparent once the building is completed and occupied. Therefore, various sections of Part 9 require the application of certain radon exclusion measures in all dwellings. These measures are

- low in cost,
- difficult to retrofit, and
- desirable for other benefits they provide.

The principal method of resisting the ingress of all soil gases, a resistance which is required for all buildings (see Sentence 9.13.4.2.(1)), is to seal the interface between the soil and the occupied space, so far as is reasonably practicable. Sections 9.18. and 9.25. contain requirements for air and soil gas barriers in assemblies in contact with ground, including those in crawl spaces. Providing control joints to reduce cracking of foundation walls and airtight covers for sump pits (see Section 9.14.) are other measures that can help achieve this objective. The requirements provided in Subsection 9.25.3. are explained in Notes A-9.25.3.4. and 9.25.3.6. and A-9.25.3.6.(2) and (3).The principal method of excluding radon is to ensure that the pressure difference across the ground/space interface is positive (i.e., towards the outside) so that the inward flow of radon through any remaining leaks will be minimized. The requirements provided in Article 9.13.4.3. are explained in Note A-9.13.4.3.

A-9.13.4.2.(3) Exception for Buildings Occupied for a Few Hours a Day. The criterion used by Health Canada to establish the guideline for acceptable radon concentration is the time that occupants spend inside buildings. Health Canada recommends installing a means for the future removal of radon in buildings that are occupied by persons for more than 4 hours per day. Sentence 9.13.4.2.(3) may therefore not apply to buildings or portions of buildings that are intended to be occupied for less than 4 hours a day. Addressing a radon problem in such buildings in the future, should that become necessary, can also be achieved by providing a means for increased ventilation at times when these buildings are occupied.

A-9.13.4.3. Providing Performance Criteria for the Depressurization of the Space Between the Air Barrier and the Ground

Article 9.13.4.3. contains two sets of requirements: Sentence (2) describes the criteria for subfloor depressurization systems using performance-oriented language, while Sentence (3) describes one particular acceptable solution using more prescriptive language. In some cases, subfloor depressurization requires a solution other than the one described in Sentence (3), for example, where compactable fill is installed under slab-on-grade construction.

Completion of a Subfloor Depressurization System

The completion of a subfloor depressurization system may be necessary to reduce the radon concentration to a level below the guideline specified by Health Canada.

Further information on protection from radon ingress can be found in the following Health Canada publications:

- "Radon: A Guide for Canadian Homeowners" (CMHC/HC), and
- "Guide for Radon Measurements in Residential Dwellings (Homes)."

A-9.13.4.3.(2)(b) and (3)(b)(i) Effective Depressurization. To allow effective depressurization of the space between the air barrier and the ground, the extraction opening (the pipe) should not be blocked and should be arranged such that air can be extracted from the entire space between the air barrier and the ground. This will ensure that the extraction system can maintain negative pressure underneath the entire floor (or in heated crawl spaces underneath the air barrier). The arrangement and location of the extraction system inlet(s) may have design implications where the footing layout separates part of the space underneath the floor.

APPENDIX B:
TECHNICAL SPECIFICATION SUMMARY FOR RADONX™ SOIL GAS VENTING SYSTEM

RadonX™ Technical Specification Summary Sheet

General – RadonX soil gas venting, engineered by IPEX Inc., is a complete Schedule 40 PVC piping system that addresses the need for venting soil gases from low-rise dwellings. When installed properly, RadonX can help reduce indoor radon concentrations. RadonX offers a full range of vent pipes, gas collection pipes, fittings and solvent cement.

Materials – RadonX PVC pipes and fittings are manufactured from compounds that comply with the material requirements of CSA B181.2 "PVC Drain, Waste and Vent Pipe and Pipe Fittings".

Compliance to Standards – RadonX pipe and fittings comply to all material and testing requirements of CSA B181.2 and ASTM D2665. RadonX piping system complies to gas leakage, pull out, torque and combustibility test requirements of ULC S636. RadonX vent pipe and fittings are listed by ULC to the standard CAN/ULC S102.2 and clearly marked with the certification logo indicating a Flame Spread Rating not exceeding 25.

Code compatibility – RadonX pipe and fittings satisfy the requirements of provincial and National Building Code 2015. Inside the building where flame and smoke requirements for combustible pipe vary, use the following:

Dimensions – RadonX pipe and fittings are offered in 4" Schedule 40 size and meet the dimensional requirements of CSA B181.2 and ASTM D2665.

Markings – In accordance with CGSB/CAN 149.11 and CGSB/CAN 149.12, each length of RadonX pipe is tagged with a warning label. All RadonX fittings are tagged with a warning label against the risk of radon gas leak if system is not installed as per IPEX installation instructions. All RadonX pipe and fittings include identification markers to indicate size, material description, product application, complying standards, date of production and manufacturer's name or trademark. The pipe will consist of two yellow print-lines located 180 degrees apart. All warning labels are in yellow. All product markings are bilingual.

Cements – RadonX solvent cement meets the performance requirements of ASTM D2564. PVC cement is in yellow colour and should be only used with RadonX soil gas venting systems.

Installation – RadonX pipe and fittings are designed and tested as a system by IPEX Inc. Mixing of pipe, fittings or joining methods from different manufacturers is not allowed as they have different joint systems and adhesives. These can result in unsafe conditions and cause radon gas leaks. RadonX pipe and fittings must NOT be used for any applications other than soil gas venting.

SOLUTIONS

RadonX™ Soil Gas Venting systems from IPEX is Canada's first PVC radon gas piping system. The product line consists of perforated gas collector and venting pipes, fittings, accessories and solvent cement.

Working together as an engineered system, RadonX safely collects and vents soil gas before it enters your home.

Protect yourself and your family with RadonX™ Soil Gas Venting

Open your IOS or Android device and scan here for more information