Government of Canada
Gouvernement du Canada
Canadian General Standards Board
Office des normes générales du Canada

CAN/CGSB-149.11-2024

Supersedes CAN/CGSB-149.11-2019

National Standard of Canada
Standards Council of Canada
Norme nationale du Canada
Conseil canadien des normes

Radon control options for new buildings

Canadian General Standards Board

Canada

Experience and excellence
Expérience et excellence

Canadian General Standards Board statement

The CANADIAN GENERAL STANDARDS BOARD (CGSB), under whose auspices this standard has been developed, is a government directorate within Public Services and Procurement Canada. CGSB is engaged in the production of voluntary standards in a wide range of subject areas through the media of standards committees and the consensus process. The standards committees are composed of representatives of relevant interests including producers, consumers and other users, retailers, governments, educational institutions, technical, professional and trade societies, and research and testing organizations. Any given standard is developed on the consensus of views expressed by such representatives.

CGSB has been accredited by the Standards Council of Canada as a national Standards Development Organization. The standards that CGSB develops and offers as National Standards of Canada conform to the requirements and guidance established for this purpose by the Standards Council of Canada. In addition to standards it publishes as National Standards of Canada, CGSB may produce other deliverables that meet particular needs, in response to requests from a variety of sources in both the public and private sectors. CGSB standards and CGSB's National Standards are developed in conformance with the policies described in the CGSB Policy and Procedures Manual for the Development and Maintenance of Standards.

CGSB's standards are subject to review and revision to ensure that they keep abreast of technological progress. CGSB will review and publish this standard on a schedule not to exceed five years from the date of publication. Suggestions for their improvement, which are always welcome, should be brought to the notice of the standards committees concerned. Changes to standards may be issued as amendments or as new editions of standards.

An up-to-date listing of CGSB's standards, including details on latest issues and amendments, is found in the CGSB Catalogue at the following Web site, http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html, along with more information about CGSB products and services.

Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

The testing and evaluation of a product or service against this standard may require the use of materials and/or equipment that could be hazardous. This standard does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to its use. CGSB neither assumes nor accepts any responsibility for any injury or damage that may occur during or as the result of tests, wherever performed.

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CGSB shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

For enforcement purposes, standards shall be considered published the final day of the month of their publication date.

Contact the Canadian General Standards Board

To obtain information on CGSB, its services and standards or to obtain CGSB publications, please contact us:

web — http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html

e-mail — ncr.cgsb-ongc@tpsgc-pwgsc.gc.ca

telephone — 1-800-665-2472

mail — Canadian General Standards Board
140 O'Connor Street, Tower East
Ottawa, Ontario Canada K1A 0S5

Standards Council of Canada statement

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

NATIONAL STANDARD OF CANADA **CAN/CGSB-149.11-2024**

Supersedes CAN/CGSB-149.11-2019

Radon control options for new buildings

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE.

ICS 13.040.20, 91.040, 91.120.99

Published June 2024 by the
Canadian General Standards Board
Ottawa, Ontario K1A 0S5

Canadian General Standards Board

Committee on Radon Mitigation

(Voting membership at date of ballot)

Co-Chairs	
Laverne Dalgleish	National Air Barrier Association (Producer interest)
Robert Stainforth	Health Canada – Radiation Protection Bureau (General interest)
General interest category	
Jeff Whyte	Consultant (Independent)
John Hockman	Consultant (Independent)
Liang (Grace) Zhou	National Research Council Canada (NRC) – Construction Research Centre
Scott Cryer	Consultant (Independent)
Simon Pietrocatelli	Public Services and Procurement Canada
Producer category	
David Kapturowski	Spruce Environmental Technologies Inc.
Larry Gill	IPEX Management Inc.
Rui Paulo	W. Ralston (Canada) Inc.
Salvatore Ciarlo	Owens Corning Canada
Tod Boss	Systemair
Regulator category	
Abdelkrim Habbouche	Régie du bâtiment du Québec
Mathieu Brossard	Health Canada – Regulatory, Operations and Enforcement Branch
Pam Warkentin	Canadian – National Radon Proficiency Program (C-NRPP)
User category	
Bob Deeks	Canadian Home Builders' Association (BC) – RDC Fine Homes
Bob Wood	Mr. Radon Inc.
Colin Dumais	Canadian National Radon Training Centre
Jack Mantyla	Canadian Home Builders' Association (National)
Marcel Brascoupé	Canadian Association of Radon Scientists and Technologists (CARST)
Randi Fox	Fox Architecture
Rob Mahoney	Radon Works
Committee Manager (non-voting)	
Sohaila Moghadam	Canadian General Standards Board

Translation of this National Standard of Canada was conducted by the Government of Canada.

Preface

This National Standard of Canada CAN/CGSB-149.11-2024 supersedes CAN/CGSB-149.11-2019, *Radon control options for new construction in low-rise residential buildings*.

This standard has been developed to apply to Canadian environments. While it may be appropriate for other jurisdictions, users outside of Canada are responsible for assessing its applicability.

Note: References to CAN/CGSB-149.12 *Radon Mitigation Options For Existing Buildings* are to the expected second edition (2024).

Changes since the previous edition

There have been several changes to CAN/CGSB-149.11-2019. These changes are as follows:

- The scope of the standard has been expanded to new buildings, not just low-rise residential buildings. For further details, see 1.1 for a statement on building applicability.
- The standard now provides technical solutions for two levels of radon control options during the construction of a building. These two levels are as follows:
  - Level 1 – radon rough-in;
  - Level 2 – passive vertical radon stack.
- Level 1 provisions now feature two types, to reflect the industry practice to sometimes extend a radon rough-in pipe to the outside through a rim-joist or sidewall. This extended rough-in is now referred to as a Level 1b system. In this standard, the conventional description of a rough-in system is now referred to as a Level 1a system.
- Details on a Level 3 system (active soil depressurization), previously described in CAN/CGSB-149.11-2019, are now only described in CAN/CGSB-149.12-2024 *Radon Mitigation Options for Existing Buildings*.
- As a result of the above changes, the title, introduction and scope of this standard have been modified.
- Figure 1 has been added for clarity regarding the components of, and relationship between Level 1a, Level 1b, Level 2 and Level 3 systems across both this standard and CAN/CGSB-149.12-2024.
- Terms and definitions, normative references and bibliography have been updated and expanded.
- Figures and tables have been added to provide further guidance on soil gas barrier installation and building clearances.
- Sections of the standard were rearranged to better reflect the order of construction of a radon control system.
- The pipe standards references have been updated to reflect the current National Building Code requirements and to add specific marking requirements for pipe products made specifically for radon gas.

The following definitions apply in understanding how to implement this National Standard of Canada:

- "shall" indicates a **requirement**;
- "should" indicates a **recommendation**;
- "may" is used to indicate that something is **permitted**;
- "can" is used to indicate that something is **possible**, for example, that an organization is able to do something.

Notes accompanying clauses do not include requirements or alternative requirements. The purpose of a note accompanying a clause is to separate explanatory or informative material from the text. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

Table of contents Page

Figures

Tables

Introduction

Purpose and intent

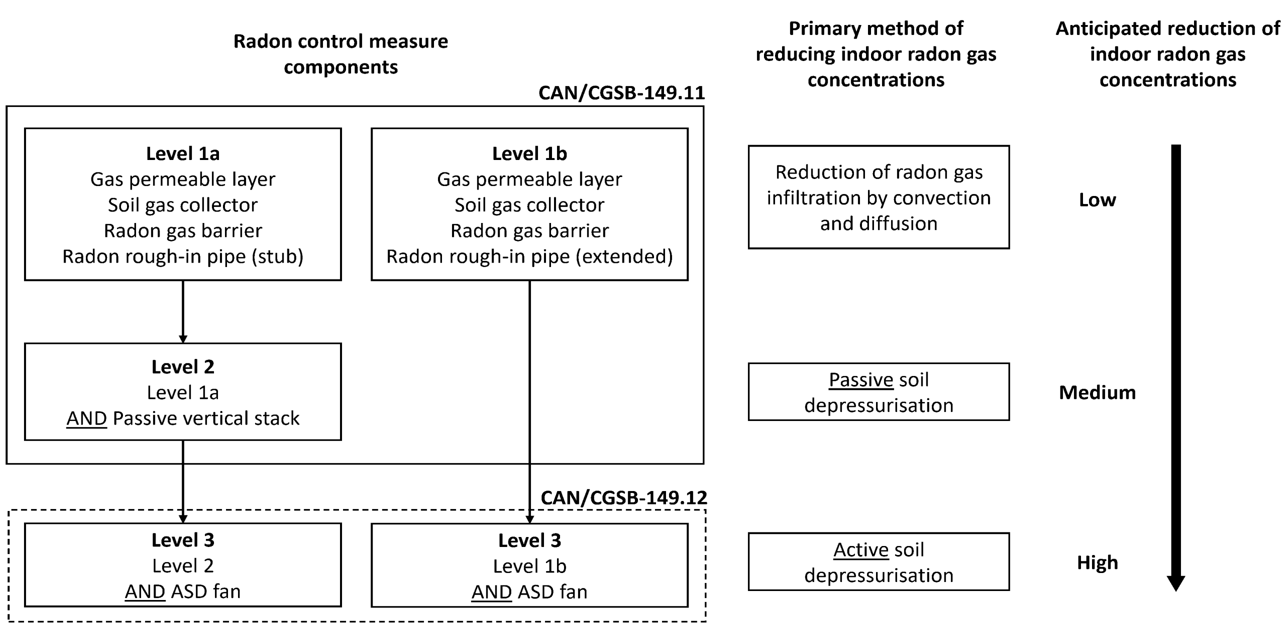
The purpose of this National Standard of Canada is to provide technical solutions for two levels of radon control options during the construction of a building – based on best-practice knowledge of techniques, materials, products, and installation.

These technical solutions are intended for use by qualified practitioners and are presented so that they can be used for conformity assessment. Additional best practice guidance is provided for voluntary action and for use by professional training and certification programs. Organizations such as the Canadian – National Radon Proficiency Program (C-NRPP) provide information and training on radon gas control and mitigation for new and existing buildings.

Note: In this standard, references to C-NRPP or approval by C-NRPP "or equivalent" refer to equivalent organizations or individuals that provide a radon proficiency program recommended by Health Canada.

This standard provides details on material/product selection and installation instructions for two progressive levels (Level 1 and Level 2) of radon control options that reduce radon gas infiltration from the ground into a new building. Level 1 features two types: Level 1a and Level 1b. Both can reduce indoor radon gas concentrations by reducing the infiltration of radon gas via convection and diffusion. Level 1a is a prerequisite for Level 2. Level 2 systems can reduce indoor radon gas concentrations by passive soil depressurization. Level 1b and Level 2 systems can be directly upgraded with an active soil depressurization (ASD) fan to a Level 3 radon control option that is the most effective at reducing indoor radon gas concentrations. CAN/CGSB-149.12, a standard for radon mitigation options in existing buildings[1], provides details on Level 3 radon control options and how those described in this standard can be upgraded to a Level 3 system. Figure 1 outlines the components of, and the relationship between, Level 1a, Level 1b, Level 2 and Level 3 systems across both this standard and CAN/CGSB-149.12, *Radon mitigation options for existing buildings*.

Figure 1 – Radon control options



[1] For this standard and CAN/CGSB-149.12, an existing building is considered a building which has been completed and is either currently occupied or ready for occupancy.

This figure outlines the system components for each level of radon control option and their method for reducing indoor radon gas concentrations. Level 1 and Level 2 systems can be upgraded to Level 3 systems (described in CAN/CGSB-149.12). The anticipated reduction of indoor radon gas concentrations increases with each sequential level.

Since indoor radon concentrations for newly constructed buildings cannot be predicted, following the requirements in this standard does not guarantee that concentrations below the Canadian guideline of 200 Bq/m^3[1] will be achieved.

Health Canada recommends that building owners conduct a long-term radon test during the first heating season once the construction of a new building is complete. If required, systems can be upgraded to a Level 3 system by following CAN/CGSB-149.12 requirements.

Technical approach and performance expectations

This standard provides two levels (Level 1 and Level 2) of radon control options. In total there are three levels, defined as follows:

Level 1 **Radon rough-in system for active soil depressurization – (CAN/CGSB-149.11)** – requirement for a passive stack (Level 2) or active system (Level 3). Level 1 systems include a gas permeable layer, soil gas barrier and soil gas collector. The barrier reduces the convection and diffusion of radon from the ground into the building. The soil gas collector is connected to a solid pipe that is accessible above the finished floor. There are two options for the installation of a Level 1 system based on the termination of this pipe, either Level 1a, where the pipe is capped and sealed within the building (typically above the floor of the lowest level), or Level 1b, in which the pipe extends outside through a rim-joist or sidewall where it is capped. The authority having jurisdiction may already require a Level 1a system for future radon mitigation in a building.

Level 2 **Passive vertical radon stack (includes Level 1a plus a stack) – (CAN/CGSB-149.11)** – requirement for an active system (Level 3), includes Level 1. Level 2 features a stack which runs vertically up through the building and exhausts above the roofline. The system reduces indoor radon gas infiltration into the building through passive soil depressurization due to the stack effect. This does not require electrical power. Research has demonstrated that Level 2 systems have reduced indoor radon gas concentrations by 40 to 90%[2-8]. The authority having jurisdiction may already require a full passive vertical radon stack for radon mitigation in a building.

Level 3 **Full active soil depressurization system (includes Levels 1a and 2 plus an ASD fan or Level 1b plus an ASD fan) – (CAN/CGSB-149.12)** – includes Level 2 or Level 1b. This is the most effective radon control system, requiring an ASD fan to operate continuously to provide active soil depressurization. A reduction of the indoor radon concentration of approximately 90% or more (in the case of high indoor radon gas concentrations) can be obtained by installing a properly implemented Level 3 [full active (ASD fan driven)] radon control system. Level 1b and Level 2 systems as described in this standard can be upgraded to a Level 3 system by the addition of an ASD fan as outlined in CAN/CGSB-149.12.

There are no areas of Canada that are radon free. However, indoor radon gas concentrations cannot be predicted prior to construction, and it is important to emphasize that individual buildings can have different indoor radon concentrations as those built in the same area. Building codes in most provinces and territories already require protection from radon gas ingress similar to Level 1a.

Radon control options for new buildings

1 Scope

This National Standard of Canada provides technical solutions for two levels of radon control options during the construction of a building, including radon gas control techniques, materials, products, and installation. These technical solutions address the following:

a) Airtightness between the building and the ground.

b) Passive depressurization of the space between the building and the ground.

The radon gas control options provide guidance for the design of the system, the choice of materials, installation requirements, as well as provide basic construction specifications to minimize radon gas entry into a building and allow for future mitigation options.

This standard specifically addresses techniques for reducing radon gas from infiltrating and diffusing into a building from the ground and facilitating depressurization.

Units of measurement – Quantities and dimensions used in this standard are provided in units from the International System of Units (SI units). Imperial equivalents may be shown in brackets, if applicable. Please refer to the local building code for local tolerances.

1.1 Application to building types

The radon control options in this standard originate from the successful application of the standard to single family dwellings. There exist known instances where the technical principles of this standard have been applied to other National Building Code of Canada (NBC) part 9 building types (e.g., semi-detached homes, townhomes, and other low-rise buildings) and schools. Therefore, under certain conditions, the technical principles in this standard may be applicable to buildings other than single family dwellings. Annex I (informative) provides guidance on some specific applications, including respective design considerations and current best practices that may help users and regulators decide for which building types to apply this standard.

This standard is not intended to provide a technical solution to every type of building; rather the technical principles included in this standard can provide base requirements for designing radon control solutions for non-typical buildings.

1.2 Exclusions

This standard does not address the mitigation techniques for radon from water and construction materials (see Annex D).

The radon gas control options presented in this standard may not be appropriate for the mitigation of radon gas in existing buildings (see CAN/CGSB-149.12, *Radon mitigation options for existing buildings*).

This standard does not address the control and mitigation of radon gas in all types of buildings. Additional details may be required for the installation in specific building types or building configurations (for example, application of this standard to some large buildings may not be appropriate). Guidance is provided in Annex I for some types of buildings.

Note: Work is typically undertaken, solely or in combination, by registered professionals possessing expertise in reducing radon gas ingress, C-NRPP certified practitioners/specialists or those permitted by the authority having jurisdiction.

The testing and evaluation of a product against this standard may require the use of materials and/or equipment that could be hazardous. This standard does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to its use.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this National Standard of Canada. The referenced documents may be obtained from the sources noted below. Additional references not featured in this standard, but may be useful can be found under 'Other useful resources' at the end of this document.

Note: The contact information provided below was valid at the date of publication of this standard.

An undated reference is to the latest edition or revision of the reference or document in question, unless otherwise specified by the authority applying this standard. A dated reference is to the specified revision or edition of the reference or document in question.

2.1 Canadian General Standards Board

CAN/CGSB-51.34-2022 – *Polyethylene sheet for use in building construction – Material specification*

CAN/CGSB-149.12-2024 – *Radon mitigation options for existing buildings*

2.1.1 Contact information

The above may be obtained from the Canadian General Standards Board. Telephone: 1-800-665-2472. E-mail: ncr.cgsb-ongc@tpsgc-pwgsc.gc.ca. Web site: www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html.

2.2 CSA Group

CAN/CSA-B70 – *Cast Iron Soil Pipe, Fittings, and Means of Joining*

CAN/CSA-B181.1 – *ABS Drain, Waste, and Vent Pipe and Pipe Fittings*

CAN/CSA-B181.2 – *PVC Drain, Waste, and Vent Pipe and Pipe Fittings*

CAN/CSA-B182.1 – *Plastic Drain and Sewer Pipe and Pipe Fittings*

CAN/CSA-B182.2 – *PSM type PVC Sewer Pipe and Fittings*

CAN/CSA-C22.2 No. 0.15:15 – *Adhesive Labels*

2.2.1 Contact information

The above may be obtained from the CSA Group, Standards Sales. Telephone: 416-747-4044 or 1-800-463-6727. Web site: https://www.csagroup.org.

2.3 ASTM International

ASTM A312/A312M – *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

ASTM A403/A403M – *Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*

ASTM B88 – *Standard Specification for Seamless Copper Water Tube*

ASTM B306 – *Standard Specification for Copper Drainage Tube (DWV)*

ASTM C834 – *Standard Specification for Latex Sealants*

ASTM C920 – *Standard Specification for Elastomeric Joint Sealants*

ASTM E1465 – *Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings* (withdrawn 2017)

ASTM F628 – *Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe With a Cellular Core*

ASTM F3128 – *Standard Specification for Poly(Vinyl Chloride) (PVC) Schedule 40 Drain, Waste, and Vent Pipe with a Cellular Core*

2.3.1 Contact information

The above may be obtained from ASTM International. Telephone: 1-877-909-2786 (USA and Canada). Web site: https://www.astm.org.

2.4 American Society of Mechanical Engineers (ASME)

ASME B16.9 – *Factory-Made Wrought Buttwelding Fittings*

ASME B16.23 – *Cast Copper Alloy Solder Joint Drainage Fittings: DWV*

ASME B16.29 – *Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings—DWV*

ASME B36.19M – *Stainless Steel Pipe*

2.4.1 Contact information

The above may be obtained from ASME. Telephone: 800-843-2763 (USA and Canada) or 646-616-3100 (outside North America). Web site: http://www.asme.org.

2.5 Other radon references

National Research Council of Canada – *National Building Code of Canada 2020: Part 9*

National Research Council of Canada – *National Plumbing Code of Canada 2020*

ANSI/AARST CCAH-2020 – *Reducing Radon in New Construction of One & Two Family Dwellings and Townhouses*

BNQ 3624-115 – *Polyethylene (PE) Pipe and Fittings for Soil and Foundation Drainage*

UL 969 – Marking and Labeling Systems

Canadian Wood Council – *Permanent Wood Foundations 2016*

2.5.1 Contact information

The National Research Council of Canada documents, the *National Building Code of Canada 2020: Part 9* and *National Plumbing Code of Canada 2020* may be obtained from National Research Council. Telephone: 1-800-672-7990 or 1-613-993-2463. E-mail: CONSTPubSales-Ventes@nrc-cnrc.gc.ca.

National Building Code: Web site: https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-building-code-canada-2020. An electronic version of the 2020 NBC is now available for free download at: https://doi.org/10.4224/w324-hv93.

National Plumbing Code: Web site: https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-plumbing-code-canada-2020. An electronic version of the 2020 NBC is now available for free download at: https://doi.org/10.4224/2ehs-dp68.

The document ANSI/AARST CCAH-2020 – *Reducing Radon in New Construction of One & Two Family Dwellings and Townhouses*, may be obtained from the following website: https://webstore.ansi.org/Standards/AARST/ANSIAARSTCCAH2020.

The document BNQ 3624-115 – *Polyethylene (PE) Pipe and Fittings for Soil and Foundation Drainage* may be obtained from BNQ. Telephone: 418-652-2238 or 1-800-386-5114. Web site: https://www.bnq.qc.ca/en.

The document UL 969 – *Marking and Labeling Systems* may be obtained from the following website: https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=32901.

The document Canadian Wood Council – *Permanent Wood Foundations 2016* may be obtained from the Canadian Wood Council. Telephone: 613-747-5544. Web site: https://cwc.ca.

3 Terms and definitions

For the purposes of this National Standard of Canada, the following terms and definitions apply.

Note: See Annex H for additional terms, definitions and conversions.

active soil depressurization (ASD)
group of radon control systems involving ASD fan-powered soil depressurization, including, but not limited to, the most common variant known as sub-slab depressurization (SSD), as well as other related techniques, such as sub-floor depressurization, sub-membrane depressurization (SMD) (e.g., In a crawl space), block-wall depressurization, sump pit and drain tubing/tile depressurization. This ASD fan-powered soil depressurization is used to draw radon-bearing soil gas away from the foundation and safely exhaust it outdoors before it can enter a building.

Note: ASD is the most effective way to reduce high radon levels in an existing building, with reductions of 90% or more being possible.

as low as reasonably achievable (ALARA)
internationally recognized guiding practice used in radiation protection.

Note: ALARA indicates that radiation doses be reduced to as low a level as practical, with economic and social factors being considered. For additional information on ALARA please see:

a) https://api.cnsc-ccsn.gc.ca/dms/digital-medias/REGDOC-2_7_1__Radiation_Protection_2021.pdf/object;

b) http://apps.who.int/iris/handle/10665/42973.

ASD fan
type of fan that is designed and approved by the manufacturer for continuous duty and for use in an ASD radon control (mitigation) system.

becquerels per cubic metre (Bq/m^3)
SI unit of measure for the concentration of radioactivity in a volume of air.

Note: One becquerel is one radioactive disintegration per second. The American unit that measures radioactivity is picoCuries per litre (pCi/L). 37 Bq/m^3 = 1 pCi/L.

building
structure used or intended to be used for supporting or sheltering any use or occupancy.

Note: For the purpose of this standard "occupancy" means "the normal occupancy area is defined as any area occupied by an individual for more than 4 hours per day." As prescribed by Health Canada: https://www.canada.ca/en/health-canada/services/publications/health-risks-safety/guide-radon-measurements-residential-dwellings.html

Canadian - National Radon Proficiency Program (C-NRPP)
national radon certification program used by laboratories, and radon measurement and mitigation professionals in Canada.

Note: C-NRPP may provide designations to individuals or companies that have met qualification requirements or are authorized by a certification program to provide radon laboratory, measurement or mitigation services.

Canadian radon guideline level
indoor radon concentration at which mitigation is recommended, which was set at 200 Bq/m^3, as established by Health Canada in 2007.

Note 1: Canada Gazette Part I, June 9th 2007: https://gazette.gc.ca/rp-pr/p1/2007/2007-06-09/pdf/g1-14123.pdf.

Note 2: For more information, see Annex A.

cold joint
contact joint between the foundation wall and the basement slab or the parts of a slab that were poured at different times.

crawl space
shallow space between a floor of a building and the ground beneath.

Note: The crawl space can have a height ranging from an order of centimetres to meters (few inches to several feet), hence the origin of the term "crawl". The crawl space may or may not be ventilated to the outdoors.

depressurization
negative pressure induced in one area relative to another.

Note: In a building during cold weather, the lower levels experience a form of depressurization as a result of the stack effect (buoyant forces acting on the warm air). The air pressure within the soil outdoors and under the building is also often higher than that in the basement, which also acts to draw soil gas into the building because of the differences in pressure.

entry points
openings in the foundation floors, walls or services (e.g., conduit, pipe etc.) in contact with the soil, which allow soil gas to enter.

exfiltration
unintended flow of indoor air out of the building through openings (e.g., holes or cracks) in the building envelope.

footing(s)
concrete, stone or wood base that supports a foundation wall or load bearing wall and is used to distribute the weight of the building or a portion of the building over the soil or the sub grade underlying the building.

gas permeable layer
layer of gas permeable material installed under the soil gas barrier that facilitates a negative pressure field (depressurization) to extend from the suction point to the foundation walls and footings. (Examples of gas permeable material include granular material and manufactured products providing gas permeability).

Note: An efficient gas permeable layer permits a radon control system to draw radon laden soil gas from the entire sub-slab area. Typical void ratios in the gas permeable layer are in the range of 35 to 40%.

geotextile drainage matting
dimpled membrane typically made from a suitable polymer (which may be high-density polyethylene (HDPE), polypropylene, etc.) with non-woven geotextile pre-attached to the dimpled core to allow air movement.

Note: The void space is created through a matrix of woven mesh, or “egg crate” support of a fabric enclosure, or hollow polymeric blocks, or other similar means. Also referred to as “vent strip”.

grade (above or below)
lowest of the average levels of finished ground adjoining each exterior wall of a building.

Note: It is not necessary to consider localized depressions in the determination of average levels of finished ground.

granular material
particulate material used in construction. Examples include screened gravel, crushed stone, sand, recycled concrete and manufactured synthetics.

infiltration
unintended movement of outdoor air or soil gas (e.g., via flow or diffusion) into a building.

joist
one of a series of horizontal or inclined structural members used to span an open space typically supporting floors, ceilings or roofs, often between beams that subsequently transfer loads to vertical members.

passive vertical radon stack
feature of building construction whereby a full-height vertical pipe run passes through heated and/or insulated portions of the building with the inlet originating beneath the slab or lowest part of a building and the outlet terminating above the roofline for the purpose of using the stack effect to depressurize the sub-slab space to exhaust radon containing soil gas without the use of an ASD fan.

Note: The passive radon stack allows one to exploit the natural stack effect within a building in order to draw radon containing soil gas from beneath the slab and expel it to the outdoors. Research has demonstrated that passive vertical radon stacks have reduced indoor radon gas concentrations by 40 to 90%[2-8], as compared to an active radon control system which can yield radon reductions of 90% or more. A passive vertical radon stack is readily converted to an active system by the installation of an ASD fan, following appropriate diagnostic measurements to confirm the system design.

pipe loop
continuous length of solid or perforated piping (depending on its application/use) extending around the inside perimeter of the foundation or load bearing wall footings.

pressure field extension
spatial extension of the area of reduced pressure that occurs under a slab, membrane/soil gas barrier or sub-floor when an ASD fan ventilates at one or more distinct points.

radon
naturally occurring radioactive element that is a gas at standard temperature and pressure.

Note: Technically, the term "radon" can refer to any of a number of radioactive isotopes having atomic number 86. In this document, the term is used to refer specifically to the isotope radon-222, the primary longest lived isotope present inside buildings. Radon-222 is directly created by the decay of radium-226, and has a half-life of 3.82 days. Chemical symbol: Rn-222.

radon level
radon gas concentration in air expressed in becquerels per cubic metre (Bq/m^3) in a particular area or space (e.g., inside a building) as measured by a radon testing device that is approved by C-NRPP or equivalent.

Note: C-NRPP approved long-term radon testing devices are commonly used to determine the average annual radon level in a building and if mitigation is required. An up to date list of C-NRPP approved long-term radon testing devices can be found at: https://c-nrpp.ca/approved-radon-measurement-devices/.

radon mitigation
act of repairing or altering a building in whole or in part for the purpose of reducing the concentration of radon in the indoor atmosphere.

radon mitigation/control system
system, component, design, or installation for reducing radon concentrations in the indoor air of a building.

radon mitigator
individual who is accredited by C-NRPP or equivalent who reduces indoor radon concentrations, and is experienced in radon mitigation.

Note: In Canada, the C-NRPP accredits and maintains lists of mitigation professionals/companies that have met qualification requirements or are accredited to provide radon laboratory measurement or mitigation services.

radon rough-in system
foundational system that aims to reduce infiltration of radon gas into a building and facilitates the future addition of more efficient and effective mitigation systems consisting of, but is not limited to, the following: gas permeable layer, soil gas collector, suction point, soil gas barrier and a rough-in pipe connected to the suction point below the soil gas barrier at one end, terminating either inside or outside of the building at the other, where it is capped, labelled and sealed.

radon rough-in pipe (extended)
pipe (including fittings and solvent cement) that connects to the soil gas collection system through the slab (or equivalent) and soil gas barrier extending fully through the building envelope, penetrating to the outside where it is capped, labelled and sealed.

Note: The pipe does not have an ASD fan to actively move the soil gas, however it is ready for an ASD fan to be added once a radon measurement shows that activation is necessary.

radon rough-in pipe (stub)
pipe (including fittings and solvent cement) that connects to the soil gas collection system through the slab (or equivalent) and soil gas barrier with a height above the finished floor of no less than 300 mm (12 in.) and is labelled and sealed with an airtight cap.

slab
layer of concrete that commonly serves as the floor of any part of a building whenever the floor is supported on a foundation or is in direct contact with the underlying granular materials or soil.

slab on grade
type of building construction where one or more portions of the foundation feature a concrete slab resting directly on the ground below it.

soil gas
gas that is always present underground, in the small pore spaces between particles of soil or in crevices inside rock and consists mostly of air with some components from the soil (such as radon and water vapour).

soil gas barrier
continuous layer installed in order to reduce the infiltration and diffusion of soil gas into a building.

Note: A soil gas barrier is often made of polyethylene, but other more radon-specific barrier materials are available (e.g., spray foam).

soil gas collection plenum
constructed enclosure for collecting radon and other soil gases, typically from under a floor slab or membrane.

soil gas collection system
collection of components providing for a gas permeable conduit that can consist of granular material, solid pipe, perforated pipe, sub-slab ventilation panels, geotextile matting, a suction pit or suction cage for collecting soil gas from within a soil gas collection plenum and connecting to the exhaust pipe system (e.g., radon rough-in pipe, passive vertical radon stack, ASD fan pipe system).

stack effect
vertical movement of air as a result of differences in indoor-outdoor air density that arise from indoor-outdoor temperature differentials which increase the buoyancy of the indoor air relative to that of the outdoor air.

Note: The buoyant force driving the stack effect increases with building height and indoor-outdoor temperature differential. In cold climates, the stack effect tends to cause air and soil gas to infiltrate the lower portions of the building and exfiltrate through the upper portions.

sub-slab depressurization (SSD)
radon mitigation technique designed to maintain lower air pressure under a floor slab, relative to the building interior above it.

Note: SSD can be either active or passive. A passive system uses the natural stack effect to draw air from the soil gas collection system below the floor slab. An active SSD system uses an ASD fan to draw the soil gas.

sub-slab ventilation panels
product that allows for effective depressurization of the sub-slab area, but may also incorporate additional features, such as providing insulation value.

suction cage
component that is intended by the manufacturer to maintain a void space in the gas permeable layer for use in a soil gas collection system.

suction pit
cavity dug out from fill and/or native soil or created by a suction cage beneath the floor slab, by which the radon rough-in pipe (via the soil gas collection system) draws soil gas from this pit.

suction point
location on the floor where the radon rough-in pipe penetrates the sub-floor to connect to the soil gas collection system.

water column (WC)
conventional pressure measurement expressed in terms of a height of a column of water rather than in pressure per unit area and typically used to express differential pressure. Water column is often measured using a manometer (e.g., U-tube) and is determined by the difference in height of two columns of water exposed to different pressures.

Note: The units of water column are often expressed in the non-SI pressure unit of inches of water column (WC). 249 Pa (pascal) = 25.4 mm water column (1 in. water column).

4 Symbols, acronyms and abbreviated terms

The following abbreviations and acronyms are used in this National Standard of Canada.

Note: See Annex H for additional terms, definitions and conversions.

ABS	Acrylonitrile-butadiene-styrene
AFCI	Arc-Fault Circuit Interrupter
ALARA	As Low As Reasonably Achievable
ASD	Active Soil Depressurization
ASME	American Society of Mechanical Engineers
ASTM	ASTM International, formally known as the American Society of Testing and Materials
ATD	Alpha Track Detector
Bq/m^3	Becquerels per cubic meter
CGSB	Canadian General Standards Board
C-NRPP	Canadian – National Radon Proficiency Program
CSA	CSA Group, formerly known as Canadian Standards Association
DWV	Drain, Waste and Vent
EIC	Electret Ion Chamber
FPTRPC	Federal Provincial Territorial Radiation Protection Committee
GSG	Galvanized Sheet Gauge
HDPE	High-Density Polyethylene
ICF	Insulated Concrete Form
NBC	National Building Code (of Canada)
PVC	Polyvinyl Chloride
SDS	Safety Data Sheet
SSD	Sub-Slab Depressurization
WC	Water Column
WHO	World Health Organization

5 Classification

Level 1: Radon rough-in system for Active Soil Depressurization (ASD) that provides minimum protection and includes a radon rough-in and soil gas barrier that reduces the convection and diffusion of radon from the ground into the building. Level 1 is not a complete radon control system but allows for easier conversion to one in the future, should it become necessary. There exist two options for a radon rough-in, which are defined based on where the capped pipe end is located:

- Level 1a: Rough-in with sealed capped end located in the building interior.

- Level 1b: Rough-in where piping penetrates rim-joist or sidewall of the building to the outdoors, where its end is capped and sealed.

Level 2: Passive vertical radon stack (includes Level 1a PLUS a stack) provides moderate protection and includes all provisions of Level 1a, with the addition of extending the pipe stub to create a full, passive (without an ASD fan) vertical radon stack system that runs upwards through the inside of the building and vents above the roof to the outdoors. The stack passes through heated portions of the building or is insulated in unconditioned portions. Level 2 is a complete passive radon control system. Research has demonstrated Level 2 systems have reduced indoor radon gas concentrations by 40 to 90%[2-8].

Level 3: Active soil depressurization system (includes [Levels 1a AND 2 PLUS an ASD fan] OR [Level 1b PLUS an ASD fan]) (CAN/CGSB-149.12) provides the highest level of protection available and includes all provisions from either Levels 1a and 2, or Level 1b with the addition of an ASD fan to create an ASD system. Level 3 is a complete radon control system. For ASD systems, an ASD fan depressurizes the gas permeable layer leading to greater radon reductions than the passive system (Level 2) described previously. Level 3 systems often reduce high radon levels by 90% or more. Details on the upgrade of a Level 1b and Level 2 system to a Level 3 system are provided in CAN/CGSB-149.12 standard. Level 3 systems can be built as part of the construction of new buildings or the mitigation of existing buildings.

6 General requirements

6.1 Determination of radon risk

6.1.1 Pre-construction assessment

Presently there are no protocols, standards or guidelines that address building site characterization for radon risk, since the level of radon in a completed building cannot be predicted prior to construction.

This standard outlines two levels (Level 1 and Level 2) of basic construction (see 6.2), which can prepare a building for the future installation of a more effective Level 3 system. Both levels reduce indoor radon gas concentrations, with a greater reduction achievable at Level 2.

6.2 Basic construction

6.2.1 Level 1 — Radon rough-in system for ASD

6.2.1.1 Level 1a provides provisions for a radon rough-in stub that passes from the gas permeable layer, through the slab (or equivalent) and terminates inside the building, as well as provisions for a sealed soil gas barrier beneath the slab (or equivalent) that reduces the convection and diffusion of radon gas from the ground into the building. Level 1a is not a complete radon control system, but facilitates conversion to one in the future, should it become necessary. The radon control options in buildings built to Level 1a shall be designed and constructed in accordance with 7.1, 8.1 and 8.2.

6.2.1.2 Level 1b provides the same provisions as Level 1a except that the radon rough-in pipe extends fully through the building envelope, penetrating to the outside through a rim-joist or sidewall, where it is capped and sealed. As such, Level 1b is a completed piping system that is ready for ASD fan installation (based on CAN/CGSB-149.12) to become a Level 3 system. The radon control options in buildings built to Level 1b shall be designed and constructed in accordance with 7.1, 8.1 and 8.2.

Note: Should long-term radon testing after completion of construction and occupancy find high radon levels, please refer to standard CAN/CGSB-149.12, *Radon mitigation options for existing buildings* for details on upgrading a Level 1 system to a Level 3 system.

6.2.2 Level 2 — Passive vertical radon stack

6.2.2.1 Level 2 includes all provisions of Level 1a, with the addition of extending the pipe stub to create a full, passive vertical radon stack system that runs upwards through the inside of the building and vents above the roof to the outdoors. The stack passes through heated portions of the building or is insulated in unconditioned portions. Level 2 is a complete passive soil depressurization radon control system. The radon control options in building units built to Level 2 shall be designed and constructed in accordance with 7.2, 8.1 and 8.2.

Note: Should long-term testing after completion and occupancy find high radon levels, please refer to standard CAN/CGSB-149.12, *Radon mitigation options for existing buildings* for details on activating a full passive radon stack system into a Level 3 system.

6.3 Construction features (special consideration)

In new construction, there are several possible features that may not be common, but that bear special consideration from a radon infiltration standpoint. See Annex I for more details.

7 Detailed requirements

7.1 Level 1 — Radon rough-in system for ASD

A radon rough-in system is composed of the following three components:

a) Soil gas collection system, composed of:

   1) Gas permeable layer;

   2) Soil gas collector;

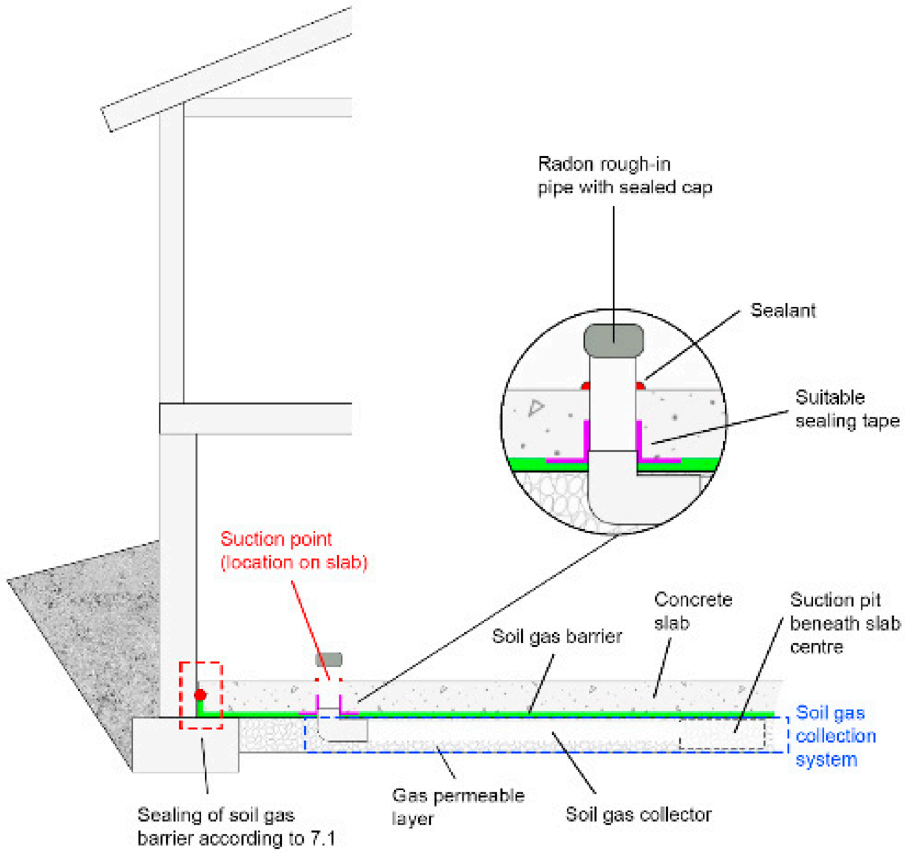
b) Radon rough-in pipe (includes pipe, fittings, cap and solvent cement);

c) Soil gas barrier.

The soil gas collection system is located below the ground contact floor slab(s) (or equivalent) of the building and is sealed with a soil gas barrier prior to pouring the slab (or equivalent). Via a suction point (a location on the floor), the rough-in pipe connects to, and extends from, the soil gas collection system through the soil gas barrier and slab (or equivalent) to above the floor inside the building (Level 1a), or extends through a rim-joist or sidewall (Level 1b) to the outside. Figures 2a and 2b illustrate two common approaches to achieving a Level 1a system. Figure 3 illustrates an example of a Level 1b system.

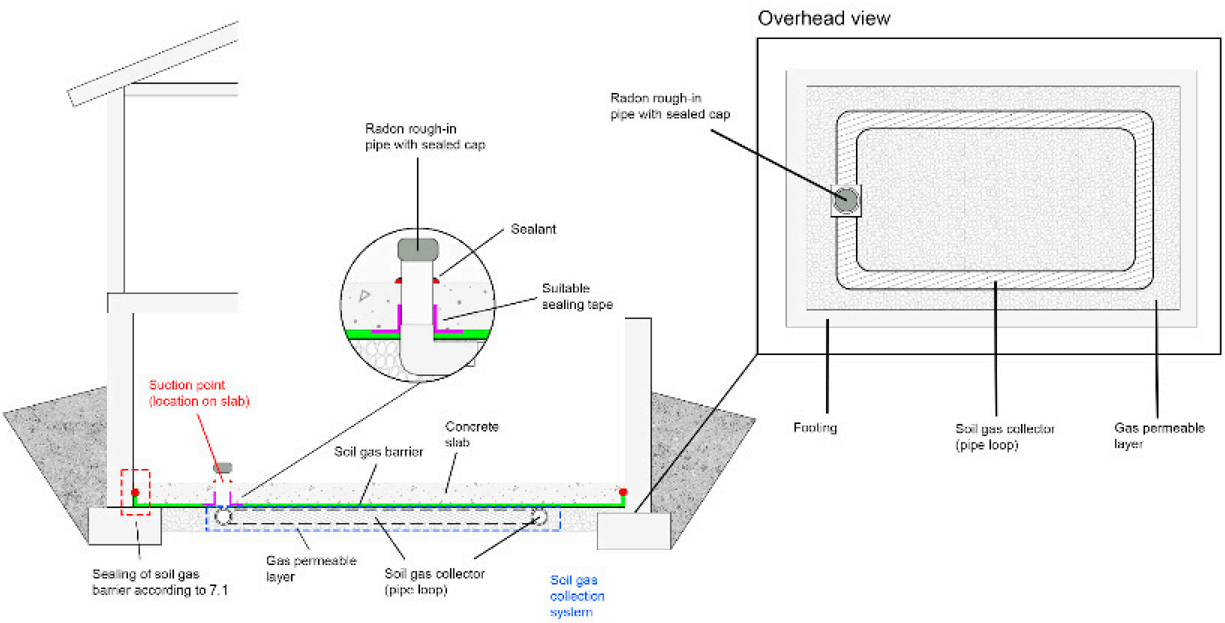
Note: Depending on the choice of materials and their configuration, the combined function of the gas permeable layer and soil gas collector (collectively, the soil gas collection system) may be achieved through the use of one or more products not illustrated in Figures 2a, 2b and 3.

Figure 2a – Illustrative diagram of a Level 1a radon rough-in system and its three components



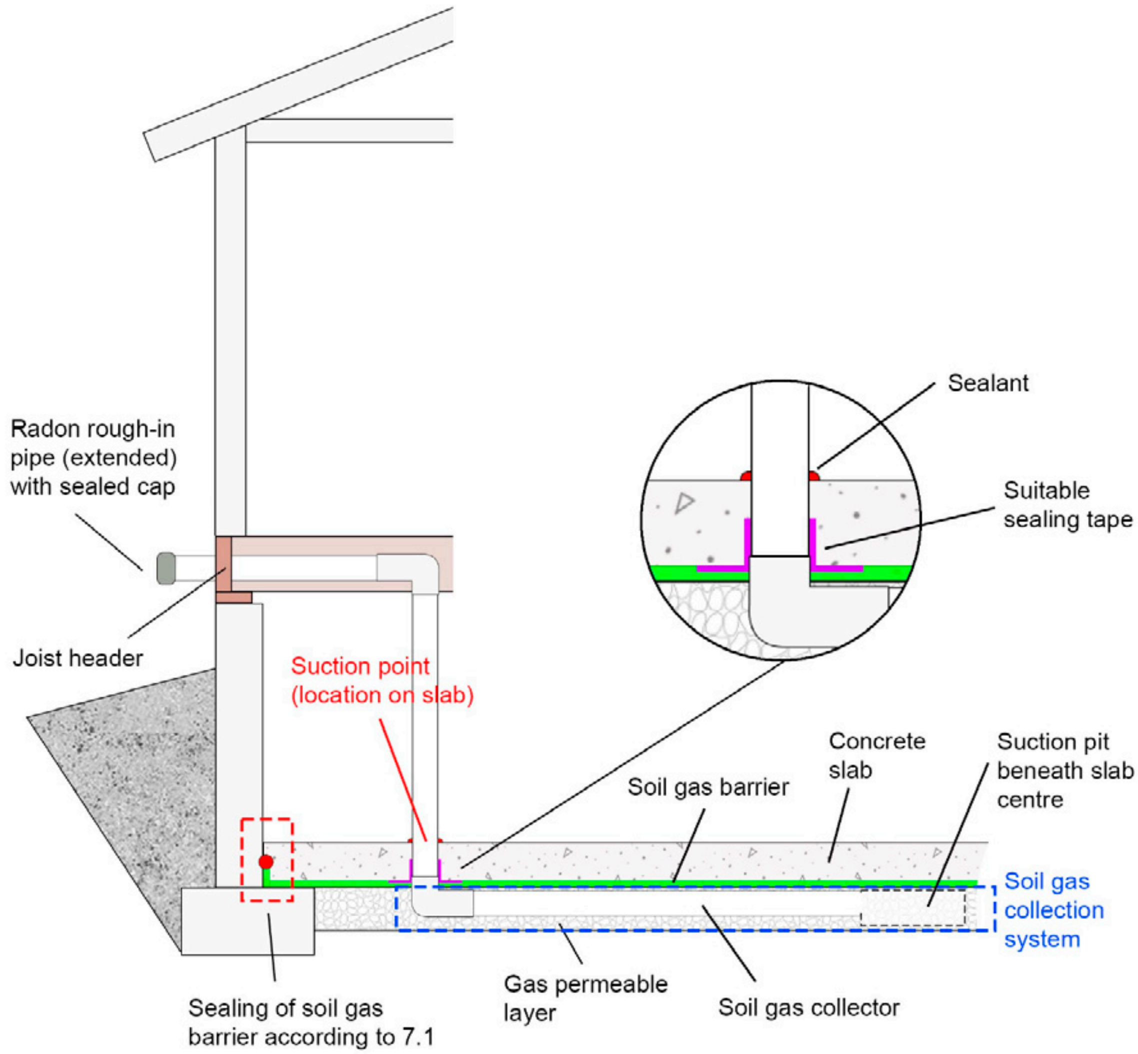
Shown is the soil gas collection system [composed of a gas permeable layer and soil gas collector (a single pipe run in this example)], radon rough-in pipe and soil gas barrier. The soil gas collector has a suction end in a suction pit within the gas permeable layer. The suction pit is located towards the centre of the gas permeable layer beneath the soil gas barrier and concrete slab. The suction point, a location on the concrete slab, is also shown.

Figure 2b – Illustrative diagram of a Level 1a radon rough-in system and its three components (alternative)



Shown is the soil gas collection system [composed of a gas permeable layer and soil gas collector (a pipe loop run in this example)], radon rough-in pipe and soil gas barrier. The soil gas collector is composed of a pipe loop (composed of perforated pipe) which provides equivalent function to that of a suction pit (see Figure 2a). Shown inset is an overhead view of the pipe loop configuration.

Figure 3 – Illustrative diagram of a Level 1b radon rough-in system and its three components



Soil gas collection system [composed of a gas permeable layer and soil gas collector (solid pipe in this example)], radon rough-in pipe and soil gas barrier. The soil gas collector has a suction end in a suction pit within the gas permeable layer. The suction pit is located towards the centre of the gas permeable layer beneath the soil gas barrier and concrete slab. The suction point, a location on the concrete slab, is also shown. The rough-in pipe extends through a sidewall or rim-joist to the outside where it is capped and sealed.

7.1.1 Soil gas collection system

7.1.1.1 A soil gas collection system shall consist of a gas permeable layer (7.1.1.4) and soil gas collector (7.1.1.5) that are located beneath a soil gas barrier below the slab (or equivalent).

Note: In a typical installation, the soil gas collection system may consist of granular material as the gas permeable layer, and a pipe construction to act as the soil gas collector to collect soil gas and conduct it to the suction point (as shown in Figures 2a, 2b and 3). The soil gas barrier should be sealed to the soil gas collector pipe where it penetrates the slab (or equivalent) so that it protects the building against radon gas infiltration or, in the case of future use as part of an ASD system, minimizes the loss of conditioned air and depressurization of the building resulting from the suction created by the ASD fan.

7.1.1.2 Each separated building or each individual unit on the lowest story of a multi-unit residential building shall be provided with a separate suction point and soil gas collection system.

7.1.1.3 Each soil gas collection system shall be provided with at least one suction point for each sub-slab area (in other words, each soil gas collection plenum) that is confined by the surrounding footings or be connected to another soil gas collector served by one or more suction points. The design chosen shall create an effective depressurization across the entire sub-slab area.

7.1.1.4 Gas permeable layer

7.1.1.4.1 A layer of gas permeable material shall be provided under all concrete slabs (or equivalent) within the building footprint.

7.1.1.4.2 The gas permeable layer shall conform to the following:

7.1.1.4.2.1 Vertical pipe, piping for utilities and horizontal conduit runs are permitted to pass through the gas permeable layer.

7.1.1.4.2.2 Horizontal runs of piping for utilities and conduit installed within the gas permeable layer shall not interfere with effective depressurization of the gas permeable layer, and any sub-slab construction horizontal runs of piping for utilities installed during construction and conduit should be installed below the gas permeable layer.

7.1.1.4.2.3 Where granular material is used for the gas permeable layer, coarse clean granular material shall be provided on the undisturbed soil to a depth not less than 100 mm (4 in.). Granular material shall contain no more than 10% of material that will pass a 4 mm (5/32 in.) sieve.

Note 1: Typically, granular material used in the gas permeable layer has a void area content of 35 to 40%, as per ASTM E1465, Table 3.

Note 2: There may be other ways to achieve a gas permeable layer under the slab. For example using inert, non-toxic, non-biodegradable, structural materials such as crushed concrete, pervious concrete, and post-industrial or post-consumer materials (crushed glass). It should be noted that the materials providing gas permeability may also fulfill other functions in the building envelope. If other structural materials aside from granular material are used, they should have an open configuration with voids that readily permit the movement of soil gas, and should not have sharp edges in order to minimize the risk of damaging the soil gas barrier from underneath. Similarly, other substitutes for granular material should not pose a risk to the soil gas barrier.

7.1.1.4.2.4 Where sub-slab ventilation panels are included in the building design as a substitute for granular material, the panels shall be placed on undisturbed soil or on compacted base following engineering design. Panels shall allow the lateral flow of soil gases to the system suction point and shall have an interconnected void area of not less than that of the granular material being substituted.

7.1.1.4.2.5 Where a uniform layer of geotextile drainage matting is included in the building design as a substitute for granular material, it shall be placed over a minimum of 100 mm (4 in.) of sand. The uniform layer of geotextile drainage matting used shall allow the lateral flow of soil gases to the system's suction point fitting and shall have an interconnected void area of not less than that of the granular material being substituted.

7.1.1.5 Soil gas collector

7.1.1.5.1 A pipe used for a soil gas collector shall meet the specifications in 7.1.3.

7.1.1.5.2 Where a solid pipe is used as a soil gas collector, it shall be constructed using 100 mm (4 in.) nominal internal diameter piping or tubing that extends into the gas permeable layer. It shall be located near or be oriented in the direction of the centre of the floor, or per manufacturer's instructions if using an alternative soil gas collection system.

Note: The installation of the soil gas collector as described complies with the performance requirements of the National Building Code of Canada.

7.1.1.5.3 Where a solid pipe is used as a soil gas collector, at the suction end of the soil gas collector (inside the gas permeable layer), the equivalent of a suction pit shall be created near the centre of the floor and be maintained under the soil gas barrier. It shall be no less than 0.014 m^3 (14 L) and the total surface area of the openings to the pit from the gas permeable layer shall be at least 0.12 m^2. Its structure shall be able to support the weight of 70 kg person and shall prevent granular material from obstructing the pipe.

Note: 7.1.1.5.3 performance mandatory requirement could be achieved by many means: suction cage, upside down polypropylene crate, sump made of bricks or blocks covered with steel mesh, end section of perforated pipe loop or T, perforated bucket, etc.

7.1.1.5.4 Where a solid pipe is used as a soil gas collector, the suction end (inside the gas permeable layer) shall not be capped.

7.1.1.5.5 Where a solid pipe is only to be used as a radon rough-in pipe and no piping of any kind is to be used as a soil gas collector within the gas permeable layer, the suction point (location) shall be located at the centre of the soil gas collection plenum (floor slab or equivalent). A suction pit shall be located below the floor at the same location. The suction end of the radon rough-in pipe in the suction pit shall meet the requirements of 7.1.1.5.1, 7.1.1.5.3 and 7.1.1.5.4.

Note 1: The NBC requires that 100 mm (4 in.) depth of granular material is provided in front of the pipe opening.

Note 2: Care should be taken not to insert the bottom end (inlet) of the pipe too deeply down into the gas permeable layer (i.e., beyond the bottom of the suction pit) in order to avoid creating flow restrictions.

7.1.1.5.6 Where a pipe loop configuration features as part of the soil gas collector, it shall consist of perforated pipe, installed not less than 450 mm (18 in.) on-centre from the inside perimeter of the foundation or footings to form a continuous loop, except to avoid obstacles.

Note 1: Where a perforated pipe is used, it should be protected from crushing and deformation. Crushed sections should be replaced.

Note 2: A soil gas collector may consist of both solid pipe and perforated pipe.

7.1.1.5.7 Where a perforated pipe is used as part of a soil gas collector, the pipe length buried in the granular material subfloor shall not be less than 3 m (10 ft) for every 46 m^2 (492 ft^2) of the soil gas collection plenum it is collecting soil gas from, or per manufacturer's instructions if using an alternative soil gas collection system. A perforated pipe should be orientated according in such a way to ensure soil gas is drawn in from the gas permeable layer and to allow drainage of condensation within the pipe to the soil (i.e., holes-down).

Note 1: A suction pit is not required when using perforated pipe as the soil gas collector.

Note 2: The 'holes-down' requirement is to ensure that the 10% of fines permitted when using granular material does not flow into the pipe and to prevent larger stones from plugging the holes.

7.1.1.5.8 Where sub-slab ventilation panels are used for a soil gas collector, they shall be installed according to manufacturer's instruction, and the radon rough-in pipe shall be connected to it according to the manufacturer's instructions.

7.1.1.5.9 Where geotextile drainage matting is used for a soil gas collector, the system shall be installed according to manufacturer's instructions.

7.1.1.6 Suction point

7.1.1.6.1 Where a solid pipe is used as a soil gas collector, the floor location where the pipe end or elbow is intended to connect to the radon rough-in pipe shall define the suction point on the floor.

7.1.1.6.2 Where a perforated pipe loop is used as a soil gas collector, the suction point shall be defined as the floor location where a component of the collector is intended to connect with the radon rough-in pipe. Such components may include the tee fitting or pipe saddle installed as part of the loop or the pipe end or elbow of a solid pipe that is connected to the perforated pipe loop through a tee or cross fitting.

7.1.1.6.3 Where geotextile drainage matting is used for a soil gas collector, the suction point location shall be compliant with manufacturer's instructions.

7.1.1.6.4 If an ASD suction point inlet is installed on a sump pit cover, the sump pit cover shall be fitted with a leak proof seal. A leak proof flexible decoupler shall also be provided to ensure that the inlet of the ASD system can be disconnected to allow for servicing of the sump area and reconnected at completion of service. See paragraph on sump pit depressurization in Annex I.

Note: Some jurisdictions may have unique requirements for sump pit venting.

7.1.2 Radon rough-in pipe

7.1.2.1 Radon rough-in location

7.1.2.1.1 A radon rough-in pipe shall be assembled according to either 7.1.2.2 for a Level 1a system or according to both 7.1.2.2 and 7.1.2.3 for a Level 1b system.

7.1.2.1.2 The rough-in location shall be compatible with one or both of the following:

a) construction of a Level 1a system (see 7.1.2.2) that can be upgraded to a Level 2 system (see 7.2), and subsequently, a Level 3 system (see CAN/CGSB-149.12);

b) construction of a Level 1b system (see 7.1.2.3) that can be upgraded to a Level 3 system (see CAN/CGSB-149.12).

Note: Cost, possible indoor pipe layout, space availability, and requirement to respect discharge clearance distances (see 7.1.2.3.4.2) may impact the location of the suction point and the type of Level 1 system chosen.

7.1.2.2 Radon rough-in pipe (stub) (Level 1a)

A pipe that passes through the soil gas barrier and slab (or equivalent) and terminates above the floor at the suction point (location).

7.1.2.2.1 The radon rough-in pipe shall be made of solid pipe and meet the specifications in 7.1.3.

7.1.2.2.2 The radon rough-in pipe shall connect to the soil gas collection system in the subfloor environment.

7.1.2.2.3 The radon rough-in pipe shall extend vertically not less than 300 mm (12 in.) above the finished floor slab (or equivalent) at the suction point (location).

Note: The top end of the radon rough-in pipe (stub) may be located in a mechanical room.

7.1.2.2.4 Where pipe (solid or perforated) is used as the soil gas collector in a soil gas collection system, the radon rough-in pipe shall connect to the soil gas collector via a suction point as described in 7.1.1.6.

Note: A single radon rough-in pipe and suction point may suffice for soil gas collection plenum areas up to 280 m^2 (3000 ft^2). However, the number of suction points in any individual building will need to be determined based on the actual footprint and geometry of the soil gas collection plenum(s) sub-slab area(s) of the building, and the pressure field extension capacity within the gas permeable layer. Where complex building and soil gas collection systems layouts exist, it is recommended that the number of suction points is established by trained individuals holding a certification such as C-NRPP designation for controlling radon in new buildings in Canada.

7.1.2.3 Radon rough-in pipe (extended) (Level 1b)

Piping that passes through the soil gas barrier and slab (or equivalent) and that extends fully through the building envelope, penetrating through a rim-joist or sidewall to the outside.

7.1.2.3.1 Where a Level 1b system is to be provided, a Level 1a system as described in 7.1.2.2 shall first be assembled, such that the radon rough-in pipe described in 7.1.2.2.2, which extends from the subfloor environment to above the finished floor, is extended with a piping run that penetrates through a nearby rim-joist or sidewall at a right angle.

7.1.2.3.2 The extended piping run described in 7.1.2.3.1 can use a combination of vertical and horizontal pipe runs, provided it penetrates through a nearby rim-joist or sidewall at a right angle. The extended pipe run shall meet specifications in 7.1.3.

7.1.2.3.3 The pipe penetration through the rim-joist or sidewall shall be watertight.

7.1.2.3.4 Provisions for future addition of an ASD fan to a Level 1b system

7.1.2.3.4.1 A Level 1b system shall meet the specifications in 7.1.2.3.4.2 and 7.1.2.3.4.3 to accommodate the future addition of an ASD fan.

7.1.2.3.4.2 Clearances outside the building

Clearances for the outlet of the extended rough-in pipe outside the building are necessary in the event the Level 1b system is upgraded to a Level 3 system by the addition of an ASD fan to actively exhaust sub-slab soil gases.

7.1.2.3.4.2.1 The outlet of the extended rough-in pipe located outside the building shall extend a minimum of 100 mm (4 in.) when uncapped from the finished surface on the exterior of the building.

7.1.2.3.4.2.2 The extended piping run described in 7.1.2.3.1 shall terminate outside of the building and should follow the suggested clearances and shall follow the required minimum clearances in Table 1.

Table 1 – Table of clearances required for the outlet of a Level 1b radon rough-in pipe

Locations	Required minimum clearances (m)	Suggested clearances (m)
Clearance from a mechanical air supply inlet	1.8	3
Clearance from a permanently closed window	0.3	1
Clearance from an openable window	1	2
Clearance from a door that may be opened	0.3	1
Clearance from a door that has an openable window	1	2
Clearance from outside corner	0.3	0.3
Clearance from inside corner (outlet of pipe shall not face inside corner)	1	1
Clearance above paved sidewalk or paved driveway located on public property	2.1	2.1
Clearance from a veranda, a porch, a deck, or a balcony	0.3	1
Vertical clearance above grade	0.3	1
Vertical clearance below soffits or from any attic venting component	1	1
Horizontal clearance from an area below the discharge where there is a risk of injury from ice falling	1	2
Horizontal clearance from the vertical line (from the ground to the roof) aligned with a natural gas relief valve termination	1	1
Horizontal clearance from the vertical line (from the ground to the roof) aligned with a propane relief valve termination	1	1
Note: The selection of the outlet point should be made considering maximal available clearances from building openings and from outdoor occupancy areas.		

7.1.2.3.4.3 Provisions for future addition of an ASD fan

7.1.2.3.4.3.1 The centre of the pipe rising above the finished floor shall be a minimum of 200 mm (8 in.) from all walls (insulated and finished) to accommodate the future installation of an ASD fan.

7.1.2.3.4.3.2 A disconnect switch or plug (on an existing branch circuit) for future use of an ASD fan should be located inside the building and above the finished floor and within visual range (to a maximum 1.8 m (6 ft) distance) of any portion of the extended rough-in pipe located inside the building and above the finished floor.

Note: If the disconnect switch or plug is connected to a circuit that features an arc-fault circuit interrupter (AFCI), this information should be disclosed to the building owner or building occupant as such circuits may impede the performance of a future ASD fan.

7.1.2.4 Rough-in pipe cap (Level 1a and Level 1b)

7.1.2.4.1 Where a Level 1a system is to be provided, a permanent sealed cap (i.e., gas tight) that is securely solvent-cemented to the opening of the pipe terminating above the top of the finished floor shall be used in order to prevent soil gas infiltration.

7.1.2.4.2 Where a Level 1b system is to be provided, a permanent sealed cap (i.e., gas tight) that is securely solvent-cemented or mechanically fastened to the outlet of the pipe penetrating the building envelope to the outside shall be used.

7.1.3 Pipe and fittings

7.1.3.1 The following are the minimum requirements for permitted pipe used in the construction of Level 1a, Level 1b and Level 2 systems.

7.1.3.1.1 Pipes shall have a nominal internal diameter of not less than 100 mm (4 in.).

7.1.3.1.2 The pipe material shall be resistant to the service environment and shall comply with 7.1.3.2.

7.1.3.1.3 All Polyvinyl Chloride (PVC), PVC cellular core, Acrylonitrile-butadiene-styrene (ABS) and ABS cellular core pipes installed completely or in part above grade shall comply with Schedule 40 specifications.

Note: Where possible, radon pipe should have a different color or identifying mark than Drain, Waste and Vent (DWV) piping. Additional information on Schedule 40 pipe can be found in ASTM E1465 and ANSI/AARST CCAH-2020 and Clause 8.1 of this standard.

7.1.3.1.4 Piping runs along the inside of hollow walls or partitions located within 43 mm (1.75 in.) of the wall/partition surface shall be protected against physical damage and puncture at wall plates, supporting members within walls or joist cavities, and any other framing members by the use of No. 16 Galvanized Sheet Gauge (GSG) (1.59 mm) plates or sleeves. The protective plates or sleeves shall be located where piping passes through notches or holes in these framing members. This provision shall not apply to piping that passes directly through walls or partitions.

Note: For example, where a horizontal pipe run passes through a hole or notch in a stud, a protective plate would be placed on the stud such that neither the stud or the section of pipe passing through, in-front or behind it could be penetrated by a nail or screw entering from the wall/partition surface.

7.1.3.1.5 Where a pipe passes through a fire separation, it shall meet the requirements of the applicable building and fire codes.

7.1.3.1.6 Horizontal pipe runs shall be minimized and when used shall be sloped for drainage of condensate to the ground by being installed with at least a 1% slope to return water to the soil.

Note 1: For the stack portion of the system, it is suggested that 22.5° fittings be used so that the stack momentum is maintained.

Note 2: Radon vent pipes should be installed without depressions (traps) in which moisture can collect. If a depression (trap) is installed, a continual drainage system should be provided to drain condensate to the soil.

7.1.3.1.7 Where horizontal pipe runs are necessary, pipes shall be supported as required by the local plumbing code for DWV piping.

7.1.3.1.8 All joining materials and practices shall be in accordance with the applicable plumbing code and the manufacturer's installation instructions.

Note: Relevant Safety Data Sheet (SDS) should be consulted before using glues, cements, primers, solvents, etc.

7.1.3.2 Acceptable pipe and fitting specifications

Where the pipe material conforms to one of the following product standards listed in Table 2, it shall be deemed to comply with 7.1.3.2 of this standard.

7.1.3.2.1 The pipe and its fittings shall conform to the product standards listed for above and below ground use as outlined in Table 2.

Table 2 – Product standards for piping and fittings and their materials

Product Standard	Material	Permitted for above or below ground use (Yes/No)	
		Above ground	Below ground
ASTM F628	Cell core ABS pipe	Yes	Yes
ASTM F3128[a]	Cell core PVC pipe	Yes	Yes
CSA B181.1	ABS pipe and fittings	Yes	Yes
CSA B181.2	PVC pipe and fittings	Yes	Yes
CSA B182.1	ABS, PP, PVC pipe and fittings	No	Yes
CSA B182.2	PVC pipe and fittings	No	Yes
ASME B36.19M	Stainless steel pipe	Yes	Yes
ASTM A312/A312M	Stainless steel pipe	Yes	Yes
ASME B16.9	Stainless steel fittings	Yes	Yes
ASTM A403/A403M	Stainless steel fittings	Yes	Yes
CSA B70	Cast iron pipe and fittings	Yes	Yes
ASTM B306 M Hard	Copper pipe	Yes	No
ASTM B306 DWV	Copper pipe	Yes	No
ASTM B88 K & L hard temper	Copper pipe	Yes	Yes
ASTM B306 K & L hard temper	Copper pipe	Yes	Yes
ASME B16.23	Copper fittings	Yes	Yes
ASME B16.29	Copper fittings	Yes	Yes

[a] In accordance to the *National Plumbing Code*, ASTM F3128 is permitted below ground only in residential buildings containing 1 or 2 dwelling units and row houses that do not exceed 3 storeys in height.

7.1.3.2.2 Where used, solid or perforated corrugated HDPE tubing should comply with BNQ-3624-115, and shall be resistant to the service environment and be used for below ground use only.

7.1.3.2.3 Pipes and fittings described in 7.1.3.2 shall be joined with products meeting the requirements of the respective pipe manufacturer.

7.1.3.2.4 Primer shall be applied where required.

7.1.4 Sealing the soil gas collection system

7.1.4.1 The soil gas collection system and all exposed soil shall be covered with a soil gas barrier.

Note: Ideally a soil gas barrier should be covered with a concrete slab.

7.1.4.2 Soil gas barriers installed over an exposed dirt crawl space shall conform to 7.1.4.5.

7.1.4.3 Soil gas barriers installed under a concrete slab shall conform to 7.1.4.6.

7.1.4.4 Sealants shall be compatible with the materials being sealed as described by the manufacturer or shall conform to the ASTM C834 or ASTM C920 standards.

7.1.4.5 Soil gas barriers over exposed dirt crawl spaces

7.1.4.5.1 An exposed dirt crawl space shall be covered with a soil gas barrier at least meeting the requirements and performance of Type 2 CAN/CGSB-51.34-2022 0.25 mm (10 mil) thick polyethylene.

Note 1: Thicker membranes may be required to cover an exposed dirt crawl space depending on the intended use of the crawl space area (e.g., if the area will be used for storage and have regular foot traffic). In such cases the membrane should be adequately protected from wear, puncture and damage.

Note 2: Polyethylene is the most commonly used material for sub-slab or membrane barriers, but other material-types can be used depending on their radon resistance and durability properties. Where alternative products designed to act as soil gas barriers are used, such as rigid panels or spray foam products, they should be installed according to the manufacturer's instructions.

7.1.4.5.2 In the case of an exposed dirt crawl space, a piece of perforated pipe should be placed on the dirt floor prior to installing the soil gas barrier membrane over the dirt crawl space.

Note 1: The intention of having the piece of perforated pipe under the membrane is to ensure that a volume or headspace is created under the membrane that acts as a soil gas collector (i.e., suction pit) and can be effectively depressurized. Typically, good depressurization is obtained between the membrane and the ground within 3.7 to 4.6 m (12 to 15 ft) of the pipe when the pipe is installed under the membrane. This rule of thumb can be used to determine the length of perforated pipe required to depressurize underneath the membrane to across the whole crawl space area.

Note 2: It is recommended that the number of suction points required be established by trained individuals e.g., someone who holds a C-NRPP designation for controlling radon in new buildings in Canada.

7.1.4.5.3 The soil gas barrier installed over a dirt crawl space shall be completely sealed and mechanically fastened to the foundation wall using a suitable method of adhesion so that it completely seals the soil gas collector from the interior building space and is constructed in a manner that prevents soil gas infiltration.

7.1.4.5.4 All joints in a sheet type soil gas barrier covering a dirt crawl space shall be lapped by 300 mm (12 in.) and sealed using a compatible sealant or joined using compatible heat-sealing methods and equipment.

7.1.4.5.5 Any tears, punctures, damage, or other deficiencies in a soil gas barrier covering a dirt crawl space shall be repaired and sealed using compatible materials.

7.1.4.5.6 Any openings in the soil gas barrier covering a dirt crawl space for plumbing, utilities, and structure shall be sealed using compatible materials.

7.1.4.5.7 A dirt crawl space should not be tied into a passive (Level 2) radon stack system. The space under a dirt crawl space will only be effectively depressurized when coupled to an active (Level 3) system.

7.1.4.6 Soil gas barriers under concrete slabs in various foundation scenarios

7.1.4.6.1 The soil gas barrier material used under a concrete slab shall at least meet the requirements and performance of Type 2 CAN/CGSB-51.34-2022 0.25 mm (10 mil) thick polyethylene.

Note: Polyethylene is the most commonly used material for sub-slab or membrane barriers, but other material-types can be used depending on their radon resistance and durability properties. Where alternative products designed to act as soil gas barriers are used, such as rigid panels or spray foam products, they should be installed according to manufacturer's instructions.

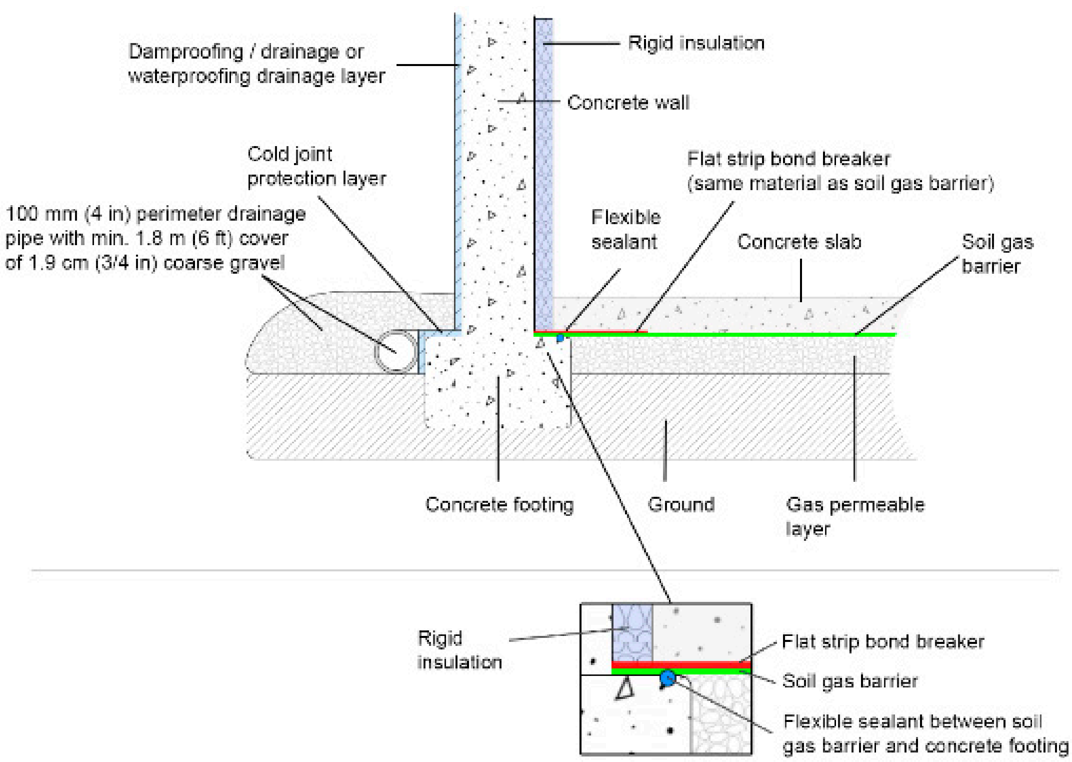
7.1.4.6.2 In all types of foundations, the soil gas barrier shall separate the soil gas collector from the building and be constructed in a manner that minimizes soil gas from entering the structure.

7.1.4.6.3 Any tears, punctures, damage, or other deficiencies in a soil gas barrier shall be sealed prior to the concrete slab being poured or prior the installation of any floor or covering.

7.1.4.6.4 Where a concrete foundation or Insulated Concrete Form (ICF) foundation is used with a concrete slab, subject to compliance with applicable code, the soil gas barrier shall be sealed to footings or foundation walls according to one of the following configurations, in Figures 4 to 9.

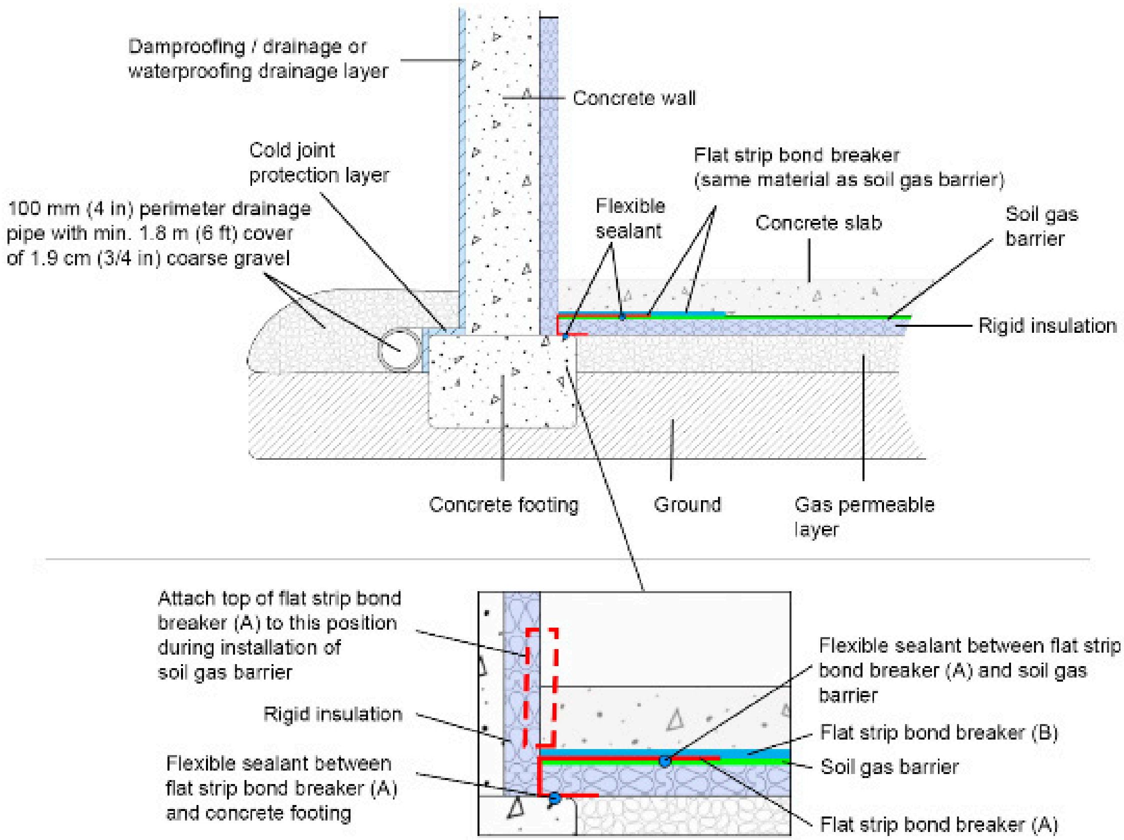
a) Where no insulation is to be laid over the soil gas barrier, the slab shrinkage shall be accommodated for with a bond break between the concrete and soil gas barrier to preserve the seal. A strip (nominal width 50 cm) should be placed along the perimeter, on top of the soil gas barrier, to act as a bond break (see Figure 4).

Figure 4 – Installation of soil gas barrier on concrete foundation (without insulation)



b) Where rigid insulation is laid beneath the soil gas barrier, a bond breaker material (nominal width 50 cm) shall be placed on top of the soil gas barrier and sealed close to the footing. The bond breaker material shall wrap over the end of the horizontal insulation (where it meets the foundation) to beneath where it shall be sealed to the concrete footing. The bond breaker material shall be covered with a second piece of bond breaker material, close to the footing, to protect it (see Figure 5).

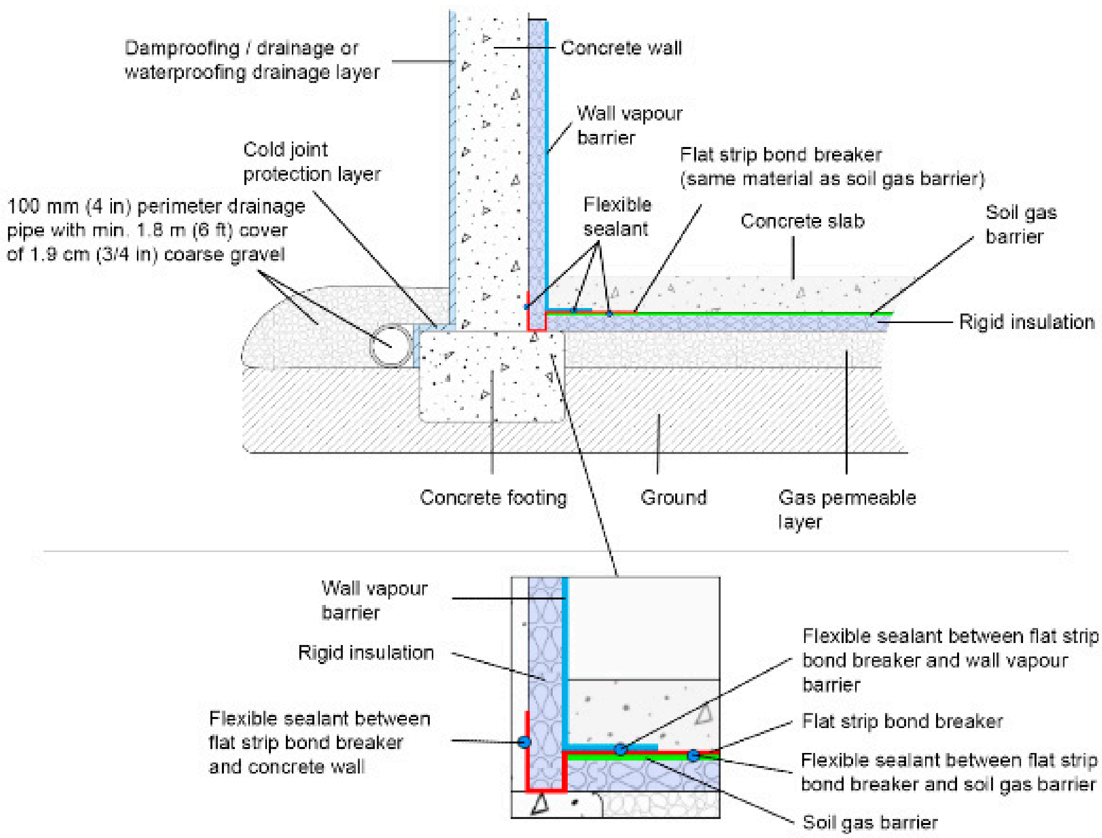
Figure 5 – Installation of soil gas barrier on concrete foundation (with insulation)



Note: The portion of the bond breaker material laid on top of the soil gas barrier may be affixed to the vertical insulation prior to the slab pour for protection.

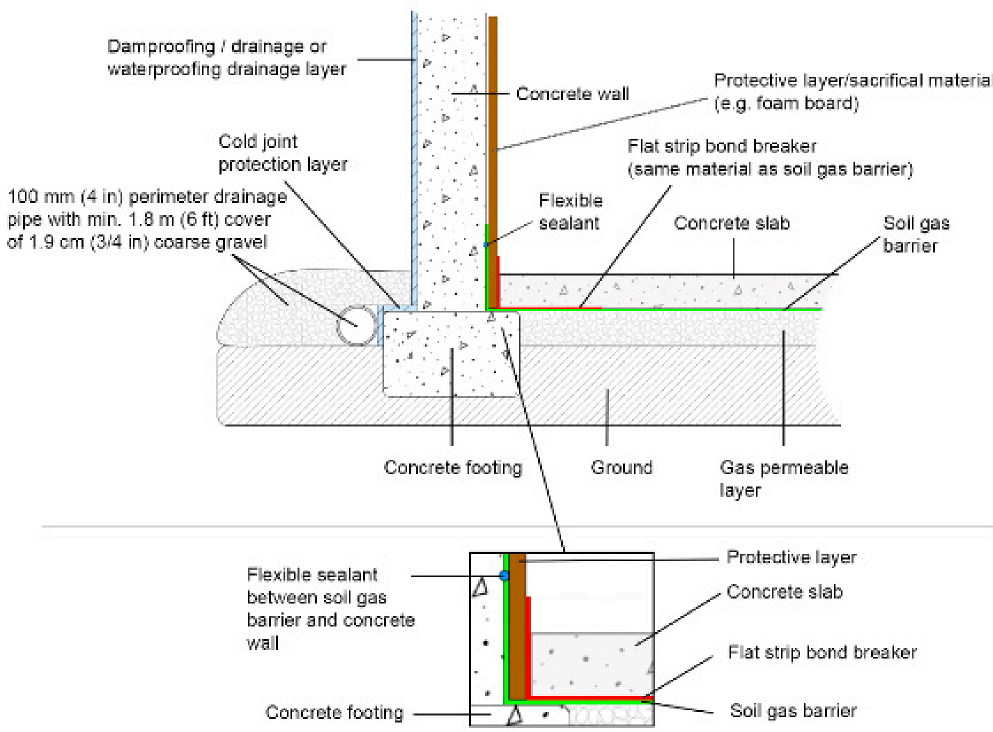
c) Where rigid insulation is laid beneath the soil gas barrier, a bond breaker material (nominal width 50 cm) shall be placed on top of the soil gas barrier and sealed to it close to the footing. The bond breaker material shall wrap over the end of the vertical insulation (where it meets the foundation) to beneath where it shall be sealed to the concrete wall. The bond breaker material shall be covered with a second piece of bond breaker material, close to the footing, to protect it (see Figure 6).

Figure 6 – Installation of soil gas barrier on concrete foundation (with insulation - alternative)



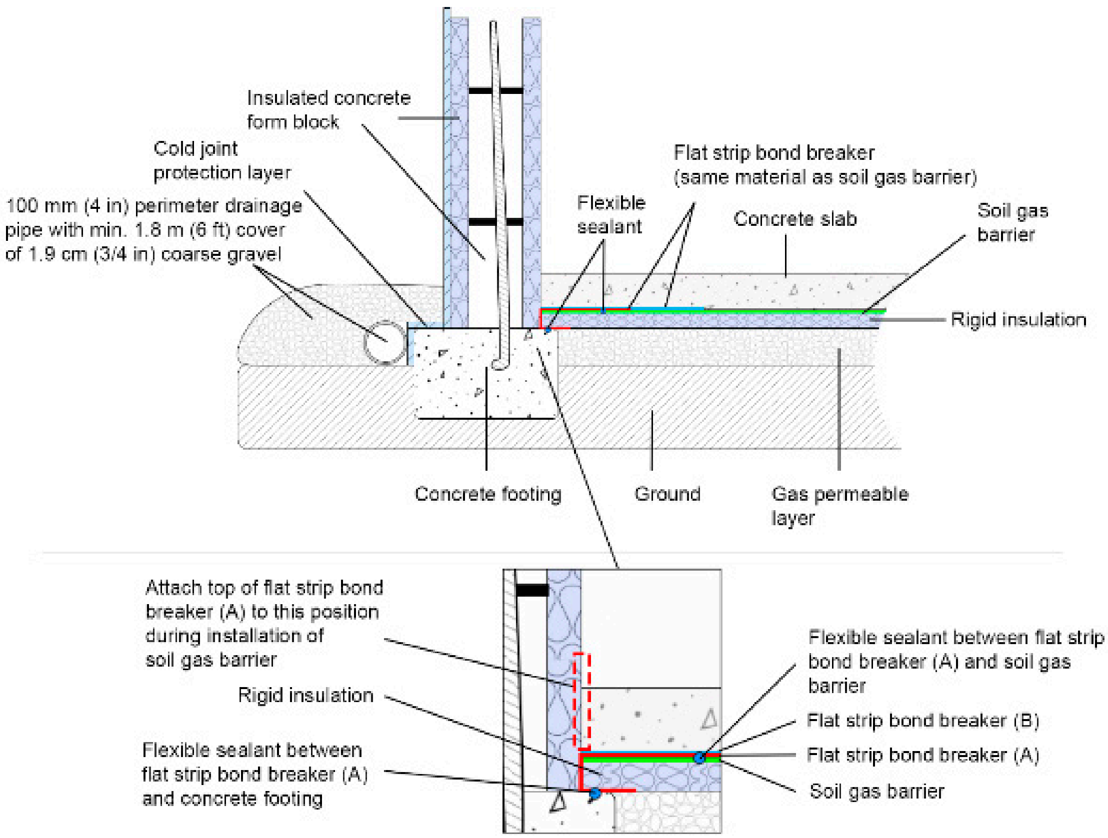
d) Where no rigid insulation is used, the soil gas barrier shall be sealed to the wall behind a vertical piece of protective material. A bond breaker material shall be located between the protective material and the concrete slab such that it extends over where the horizontal part of the soil gas barrier meets the concrete footing beneath the concrete slab (see Figure 7).

Figure 7 – Installation of soil gas barrier on concrete foundation (without insulation - alternative)



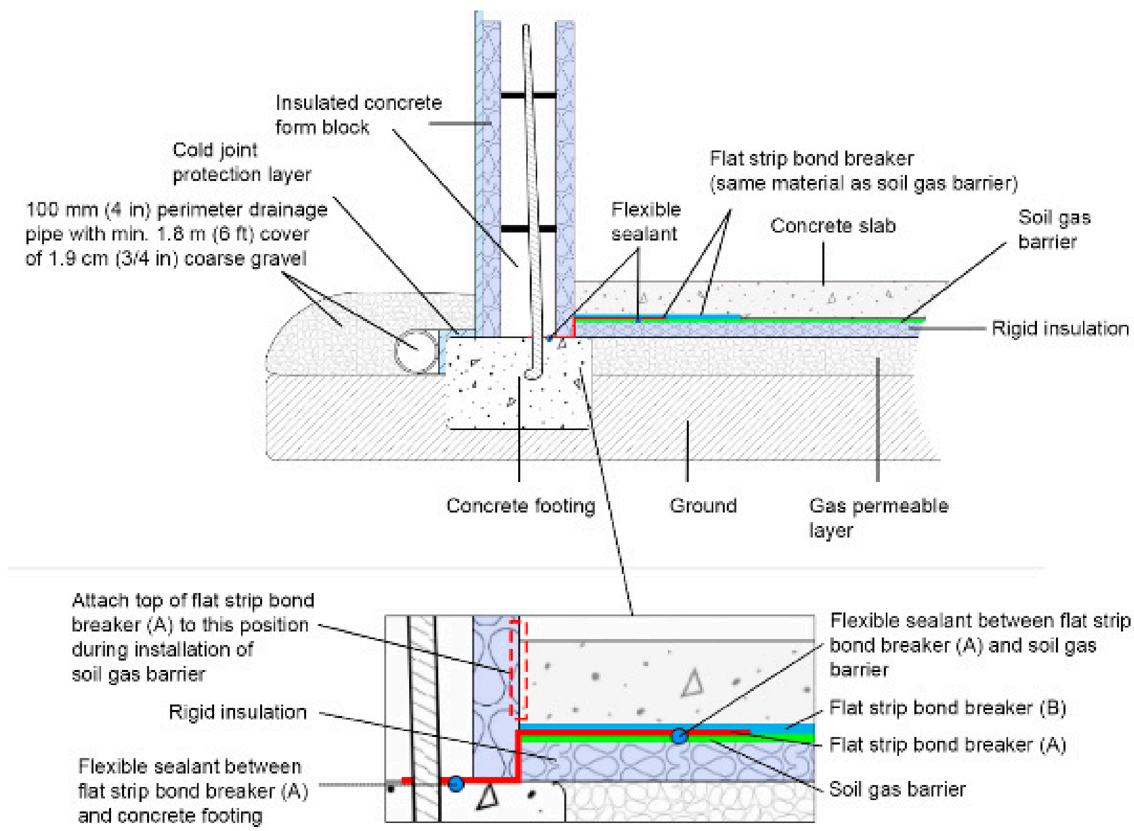
e) Where ICF blocks are used, a bond breaker material (nominal width 50 cm) shall be placed on top of the soil gas barrier and sealed to it close to the footing. The bond breaker material shall wrap over the end of the horizontal insulation (where it meets the foundation) to beneath where it shall be sealed to the concrete footing. The bond breaker material shall be covered with a second piece of bond breaker material, close to the footing, to protect it (see Figure 8).

Figure 8 – Installation of soil gas barrier on ICF foundation



f) Where ICF blocks are used and prior to the pouring of the blocks, a bond breaker material (nominal width 50 cm) shall be placed on top of the soil gas barrier and sealed to it close to the footing. The bond breaker material shall wrap over the end of the horizontal insulation (where it meets the foundation) to beneath the ICF block where it shall be sealed to the concrete footing. The bond breaker material shall be covered with a second piece of bond breaker material, close to the footing, to protect it (see Figure 9).

Figure 9 – Installation of soil gas barrier on ICF foundation prior to block pour (alternative)



7.1.4.6.5 Where a soil gas barrier is to be installed in a permanent wood foundation, it shall be installed according to the document *Permanent Wood Foundations*, 2016, by the Canadian Wood Council.

Note: Example configurations of a soil gas barrier in a permanent wood foundation can be found in Annex I.

7.1.4.6.6 Where the foundation is concrete or masonry, and where the slab meets another portion of the slab or the foundation wall, the soil gas barrier shall be lapped and clamped or otherwise be completely sealed with a sealant that is compatible and adheres to the substrates to which it is applied. Where necessary, a primer shall be used as required by manufacturer's instructions.

7.1.4.6.7 Openings in the soil gas barrier for plumbing, utilities, and structure shall be sealed. Any tears or punctures shall be sealed using compatible materials.

7.1.4.6.8 Where rigid insulation panels or spray-foam is installed under the concrete slab and does not meet the material requirements for a soil gas barrier in 7.1.4.6.1 and is not sealed as a soil gas barrier, a soil gas barrier shall be installed above the rigid insulation.

7.1.4.6.9 All joints in the soil gas barrier shall be lapped a minimum of 300 mm (12 in.) and sealed using a compatible sealant.

7.1.4.6.10 The concrete slab and foundation wall shall be installed, caulked, and sealed at all joints, intersections, and penetrations as required by the local building code.

7.1.5 Sealing entry points in the slab

7.1.5.1 Where a sump exists, a sealed sump cover shall be provided with a rigid lid that is hermetically sealed either with a mechanically compressed gasket, silicone caulking, or a purchased or fabricated system. Any penetrations through the lid shall be sealed. Where the sump basin penetrates the slab, the joint between the slab and the lid shall be sealed with a compatible sealant.

7.1.5.2 Floor drains, condensate drains, and foundation drains shall be designed and installed to ensure all drains maintain a water-tight seal in the trap.

7.1.5.3 Openings through the slab for plumbing fixtures (e.g., bathtub or shower cut outs) shall be sealed to maintain the continuity of the air/soil gas barrier, and to prevent soil gas infiltration.

7.1.5.4 Other penetrations through the slab, including access openings, shall be designed, and installed to prevent the ingress of soil gas.

7.1.5.5 Polymeric or rubber materials may be used to provide a seal where components such as posts, columns or pipes penetrate the basement slab.

Note: A good seal around the membrane and slab to reduce radon ingress is obtained using the process as shown in the UK's Building Research Establishment (BRE) *BR 211-Radon-Guidance on protective measures for new buildings* (2015 Edition) guidance document in Figure 26, Page 18. Seals may also be fabricated on-site using appropriately cut, shaped, overlapped, and taped pieces of membrane material. Care should be taken in the case of teleposts, since these are often hollow and have open adjustment holes inside the basement that may present an entry path for radon. The hollow centre can be sealed with expanding foam and the annulus between the telescoping steel members can be filled with caulking.

7.1.6 Sealing entry points in the foundation

7.1.6.1 For foundation walls constructed of hollow masonry units, the top course shall be made of solid masonry units or shall be fully grouted. In addition, the top course under door and window openings shall also be solid masonry units or fully grouted to prevent soil gas leakage.

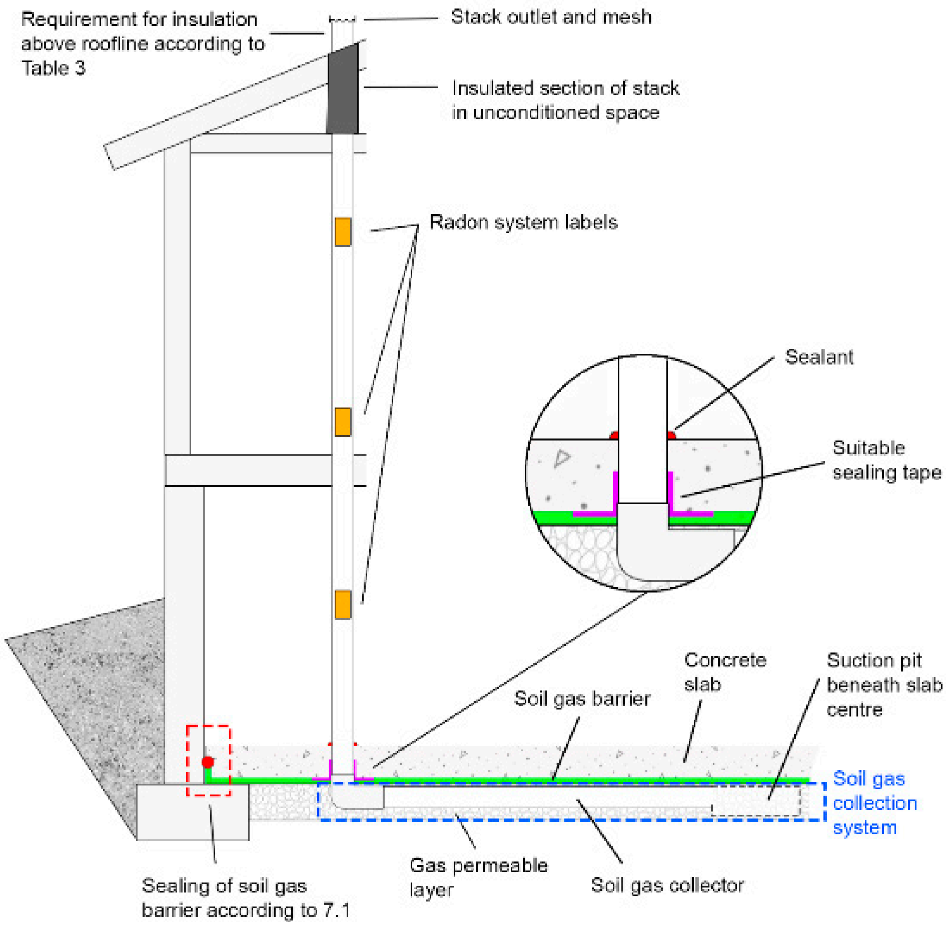
7.1.6.2 Other penetrations through foundation walls shall be sealed with appropriate materials.

7.1.7 Applicable normative requirements from Sections 8, 9 and 10 of this standard shall be applied.

7.2 Level 2 — Passive vertical radon stack

A Level 2 system extends a Level 1a system by the addition of a vertical stack that extends up through the building and above the roof. An illustrative diagram is shown in Figure 10.

Figure 10 – Level 2 system – Illustrative example of a passive vertical radon stack (not to scale)



A radon rough-in pipe rises through the floor towards the edge of the concrete slab and is extended as a passive vertical radon stack that terminates above the roofline. The termination point is open to the environment and permits air flow. In the unconditioned space below the roof, the stack is insulated.

7.2.1 Includes Level 1a

The construction of a passive vertical radon stack (Level 2) requires compliance with the provisions of 7.1 for the assembly of a Level 1a radon rough-in system, in addition to the requirements in 7.2.

7.2.2 Passive stack

7.2.2.1 The radon rough-in pipe (stub) (Level 1a), as described in 7.1 shall be extended vertically and terminated outdoors, as required in 7.2.4 and 7.2.5.

Note: The system relies on the naturally occurring stack effect to draw radon containing soil gas from beneath the slab and exhaust it outdoors in order to further reduce indoor radon levels. The discharge should ideally be above the highest roof line in order to maximize the height of the stack, which in turn should lead to greater radon reductions.

7.2.2.2 Passive stacks shall be installed in the vertical direction. Where necessary, horizontal offsets in the passive stack shall be made with 22.5° fittings.

7.2.2.3 The section of the passive vertical radon stack inside the building shall be surrounded by conditioned air on all sides except when passing through unconditioned spaces where 7.2.2.4 shall apply.

Note: Exposing all sides of the pipe to ambient indoor temperatures (such as inside an interior wall cavity) helps to maintain the passive stack effect.

7.2.2.4 The portion of the passive vertical radon stack passing through unconditioned space (e.g., an attic) shall be insulated in conformance with Table 3 with a vapour barrier applied to the exterior of the insulation. This is to maintain the stack effect flow momentum and to minimize condensation on the inside of the pipe.

Table 3 – Required amount of insulation for vertical radon stacks passing through unconditioned spaces

2.5% outdoor winter design temperature (°C)[a]	**Maximum outlet height above roof (m)**	**Insulation, RSI**					
		0.704	1.409	2.113	2.818	3.522	4.227
		Insulation, R-value					
		4	8	12	16	20	24
		Maximum length of stack in unconditioned space (m)					
-5 or warmer	0.30	4.71	6.86	7.92	9.45	10.48	11.70
Between -6 and -11	0.30	2.59	3.91	4.83	5.53	6.29	6.86
Between -12 and -17	0.30	1.28	2.59	3.08	3.43	3.78	4.11
Between -18 and -24	0.15	1.25	1.94	2.47	2.93	3.32	3.63
	0.30	0.64	0.98	1.28	1.52	1.68	1.86
	0.30[b]	1.51	2.32	2.93	3.47	3.90	4.30
Between -25 and -29	0.15	1.16	1.52	1.95	2.32	2.62	2.90
	0.30	0.40	0.61	0.76	0.91	1.04	1.16
	0.30[b]	1.34	1.92	2.47	2.90	3.26	3.60
Between -30 and -34	0.15	0.94	1.22	1.58	1.83	2.07	2.32
	0.30	0.21	0.30	0.40	0.46	0.52	0.58
	0.30[b]	1.25	1.65	2.10	2.47	2.77	3.05
-35 or colder	0.15	0.76	0.98	1.25	1.52	1.71	2.59
	0.15[b]	1.22	1.65	2.07	2.44	2.77	3.05
-35 or colder	0.30[b]	1.05	1.28	1.74	2.01	2.29	2.53

[a] Values found in NBC Table C-2: Climatic Data for Selected Locations in Canada.

[b] Outlet pipe insulated with RSI 0.704 (R4) insulation above roofline.

7.2.2.5 The maximum height of the stack outlet above the roof and the stack in unconditioned space shall follow Table 3.

7.2.3 Pipe and fittings

7.2.3.1 Pipe and fittings shall conform to 7.1.3.

7.2.3.2 The entire portion of the passive vertical radon stack to be installed within the conditioned space of the building shall be tested for leaks by either one of the following two methods described in 7.2.3.2.1 or 7.2.3.2.2.

7.2.3.2.1 The standard hydraulic test consists of capping the bottom end of the passive vertical radon stack column and filling it with water from the top end. The pipe system shall be visually inspected for leaks while the water level is maintained for 15 minutes.

Note: Standard hydraulic tests for determining leak tightness of pipe assemblies are documented in best practice guidance documents or in the applicable plumbing codes.

7.2.3.2.2 The standard air pressure test consists of sealing the passive vertical radon stack at both ends and pressurizing the pipe interior with air to 35 kPa (5 psi). The pressure shall be maintained for 15 minutes and the pipe system shall be inspected for pressure loss (i.e., leaks) by conducting a soap test on each joint.

Note: Standard air pressure tests for determining leak tightness of pipe assemblies are documented in best practice guidance documents or in the applicable plumbing codes.

7.2.4 Mitigation system termination

7.2.4.1 The passive stack for the radon control system shall terminate outdoors above the roof.

Note 1: It is not required to terminate above the highest point of the roofline.

Note 2: To maximize the efficacy of the passive stack, the highest roof of the building is recommended to be chosen.

7.2.4.2 The outlet shall be open to the environment and permit air flow.

7.2.4.3 The passive stack shall not penetrate the roof in a roof valley.

7.2.4.4 A passive stack shall not be installed as a sidewall discharge near ground level.

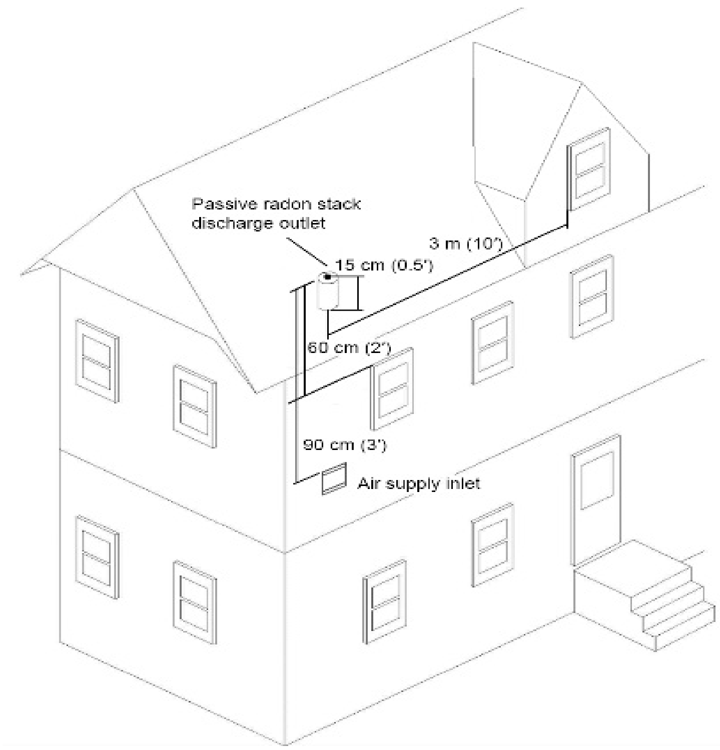
7.2.4.5 The exterior pipe termination of the passive stack terminated above the roof top shall be directed vertically conforming to Table 4. An example is shown in Figure 11.

Table 4 – Minimum passive radon stack termination clearances for roof top discharge

Location	Minimum dimension (m)
Vertical clearance above the roof at the point of penetration[a]	0.15
Vertical clearance above windows or doors	0.6
Vertical clearance above mechanical air supply inlet (air intake)	0.9
Horizontal clearance from windows, doors or mechanical air supply inlet	3
Clearance horizontally from a vertical wall that extends above the roof penetrated	3

[a] Unless specified by Table 3.

Figure 11 – Example illustration of rooftop passive stack discharge geometry showing proximity to windows and height above roof



7.2.4.6 In all discharge types, the end of the discharge pipe for the passive vertical radon stack shall be protected by a low pressure drop stainless steel mesh with 10 mm (3/8 in.) to 12.5 mm (1/2 in.) openings, or by a product providing equivalent performance. When using a product other than metal mesh, it shall have equivalent airflow performance.

7.2.5 Future system activation provisions

7.2.5.1 The portion of the stack passing through unconditioned space shall be provided with a cylindrical space not less than 500 mm in diameter and not less than 1000 mm high to facilitate future ASD fan installation if required. If the stack does not pass through any unconditioned space, the same cylindrical space to facilitate future ASD fan installation shall be provided in a conditioned space.

7.2.5.2 An electrical receptacle connected to an existing branch circuit shall be located within line of sight and within 1.8 m (6 ft) of the future ASD fan location described in 7.2.5.1.

Note 1: Arc-fault circuit interrupter (AFCI) requirements apply to all circuits with receptacles of 20A or less. If an ASD fan is hardwired, the AFCI requirements will not apply. If a rough-in receptacle is provided only, the circuit of the rough-in will have to be AFCI protected.

Note 2: It is recommended to not install the receptacle on a dedicated branch circuit to ensure that if the circuit loses power, other appliances connected to the same circuit as the receptacle (and thus, the ASD fan) will alert the occupant that the radon system may no longer be operating.

7.2.5.3 Access shall be provided for the future ASD fan location for the purposes of installation and replacement, service, repair, maintenance, and pressing the reset button on the AFCI.

7.2.6 Applicable normative requirements from Sections 8, 9 and 10 of this standard shall be applied.

8 Labelling

8.1 Labelling and marking

Labels serve the purpose of identifying the radon control system to someone performing future work in the building. They also identify the system to the building occupants who may be unaware of radon and/or its control options. There are six label types: soil gas collector (pipe) labels, radon rough-in and passive stack pipe labels, sump labels, ASD fan electrical receptacle labels, electrical panel labels and labels for soil gas barriers where the barrier will remain visible (e.g., crawl spaces).

8.1.1 Labels shall be water-resistant.

Note: CSA C22.2 No. 0.15:15 and UL 969 are two standards detailing permanent adhesive labels intended for use indoors or outdoors on application surfaces.

8.1.2 Labels shall be in both official languages.

8.1.3 Labels shall be applied to clean dry surfaces and otherwise well adhered.

8.1.4 Labels shall use lettering that is in a contrasting colour to the background.

8.1.5 Level 1a and Level 1b requirements

8.1.5.1 Soil gas barrier and soil gas collector (pipe) labels

8.1.5.1.1 Where a ground covering sealed soil gas barrier is used (such as in crawl spaces), labelling shall be located on the soil gas barrier in a prominent location, and shall state the following in both official languages: "This is a component of a radon control rough-in system. Do not tamper with or disconnect. For information related to radon, visit https://www.canada.ca/radon" and "Composant d'un système d'atténuation du radon. Ne pas modifier ou démonter. Pour plus d'information sur le radon, consultez le site https ://www.canada.ca/radon".

Note: A sufficient number of labels should be used when the soil gas barrier covering can be prominently viewed from multiple locations

8.1.5.1.2 Where pipe manufactured specifically for radon mitigation is used as the soil gas collector, it shall be marked, in a print with contrasting colour, with the following at minimum 1.8 m (6 ft) intervals:

a) "Soil Gas Venting";

b) Pipe size;

c) "Sch 40";

d) Manufacturer's production information;

e) Certification marks.

8.1.5.2 Radon rough-in pipe labels

8.1.5.2.1 Where a Level 1a or Level 1b system is provided, the cap of the rough-in pipe shall be identified with labelling containing the following information in both official languages: "This is a component of a radon rough-in system. Do not tamper with or disconnect. Remove only during installation of an active radon mitigation system. For information related to radon, visit https://www.canada.ca/radon" and "Composant d'un système du radon. Ne pas modifier ou démonter. Enlever uniquement pendant l'installation du système d'atténuation du radon. Pour plus d'information sur le radon, consultez le site https://www.canada.ca/radon". The label shall be applied to the sealed cap at the top of the stub.

8.1.5.2.2 Where a Level 1b system is provided, the radon rough-in piping located in the interior of the building shall be labelled, in view and at least every 1.8 m (6 ft) with labelling containing the following information in both official languages: "This is a component of a radon rough-in system. Do not tamper with or disconnect. For information related to radon, visit https://www.canada.ca/radon" and "Composant d'un système du radon. Ne pas modifier ou démonter. Pour plus d'information sur le radon, consultez le site https://www.canada.ca/radon".

8.1.5.2.3 Where pipe manufactured specifically for radon mitigation is used for the radon rough-in piping in the interior of the building, in a print with contrasting colour, with the following at minimum 1.8 m (6 ft) intervals:

a) "Soil Gas Venting";

b) Pipe size;

c) "Sch 40";

d) Manufacturer's production information;

e) Certification marks.

8.1.5.3 Sump labels

Where sumps are installed and used as an inlet for an ASD system, the sealed sump pit cover shall be provided with a water-resistant labelling containing the following information in both official languages: "This is a component of a radon control system. Do not tamper with or remove sump cover except for situations where the sump area requires servicing. Re-seal the sump pit (and re-install ASD piping connections and turn ASD fan back on) after servicing." and "Composant d'un système d'atténuation du radon. Ne pas modifier ou enlever le couvercle de puisard, sauf dans le cas où le secteur du puisard a besoin d'entretien. Resceller le puisard (et raccorder la tuyauterie de la DAS et remettre le ventilateur en fonction) après l'entretien".

8.1.6 Level 2 requirements

8.1.6.1 Level 1 labelling

Buildings constructed with a Level 2 system shall include the labelling provisions of Level 1a (see 8.1.5) in addition to the following requirements.

8.1.6.2 Pipe labels

8.1.6.2.1 The piping for the passive vertical radon stack shall be identified through labelling that reads as follows in both official languages: "This is a component of a radon control rough-in system. Do not tamper with or disconnect. For information related to radon, visit https://www.canada.ca/radon" and "Composant d'un système d'atténuation du radon. Ne pas modifier ou démonter. Pour plus d'information sur le radon, consultez le site https://www.canada.ca/radon". The label shall be applied at least every 1.8 m (6 ft) or at every change in direction. The labels shall be applied before wall cavities are closed.

8.1.6.2.2 Where pipe manufactured specifically for radon mitigation is used for the passive stack, in a print with contrasting colour, with the following at least 1.8 m (6 ft) intervals:

a) "Soil Gas Venting";

b) Pipe size;

c) "Sch 40";

d) Manufacturer's production information;

e) Certification marks.

Note: Example of markings are printed text on the product or permanent labels on the product.

8.1.7 Electrical panel and receptacle labels

8.1.7.1 The electrical panel providing power to the ASD fan(s) shall have labelling appropriately displayed on it with the following text, in both official languages: “An electrical rough-in receptacle has been provided in the <*insert location*> for addition of an ASD fan to allow easy conversion to an active Level 3 system if required. Do not use for any other electrical installation” and “Une prise de courant a été posée dans <*insérer l’emplacement*> en prévision de l’ajout d’un ventilateur de radon pour faciliter la conversion en un système de niveau 3 si nécessaire. Ne pas utiliser pour d’autres installations électriques”.

8.1.7.2 The electrical receptacle(s) installed for future use by ASD fan(s) shall be labelled with the following text, in both official languages: “For use with ASD radon fan” and “A utiliser avec le ventilateur de radon ASD”.

8.2 Radon maintenance and information sheets

For each level of radon control option installed in a building during construction, an information sheet shall be provided to the building owner. The two levels of radon control options shall each have a unique information sheet. The information sheets shall follow the formats shown in Tables 5, 6, and 7.

Table 5 – Radon rough-in system (Level 1a)

Radon system specification: CGSB ___________

Type: Level 1a radon rough-in system for active soil depressurization

Upgrade option: 1) Convert to a passive vertical radon stack (Level 2 system) by installing an additional vertical piping run terminating above the roofline, or 2) convert to an active soil depressurization system (Level 3) with additional piping and an ASD fan.

Description: A radon rough-in system is installed in this building. This system is not operational. The cap on the end of the radon rough-in pipe stub needs to remain sealed and in-place until such time that it is converted to either a passive vertical radon stack (Level 2 system) or to an active soil depressurization (with an ASD fan) system (Level 3) by trained individuals that hold a C-NRPP designation for radon mitigation in Canada.

Radon testing: Test the building for radon during the first heating season after occupancy by completing one of the following:

a) Perform a long-term radon test (three-month test) that is approved by C-NRPP or equivalent.

b) Hire a radon measurement provider certified by a program such as C-NRPP or equivalent to perform a long-term radon test (three-month test).

c) Perform a test for a minimum of three months using a digital radon monitor that has passed C-NRPP's performance test (see note 2).

Note 1: An up-to-date list of C-NRPP approved long-term radon test devices can be found at: https://c-nrpp.ca/approved-radon-measurement-devices/.

Note 2: C-NRPP periodically reports on the performance of digital radon monitors available to Canadian consumers. The most recent report, which includes guidelines for using digital radon monitors, can be found here: https://c-nrpp.ca/wp-content/uploads/2023/10/Digital-Device-Report-Oct-2023.pdf.

Note 3: C-NRPP professionals can only provide long-term radon testing services that make use of C-NRPP approved radon test devices.

The building should be re-tested for radon every five years, or as recommended by Health Canada. Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m^3, take steps to upgrade and activate the radon control system as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Building owner maintenance: Some components of this radon rough-in system require maintenance and monitoring by the building owner or occupant (e.g., in dirt crawl spaces with an exposed membrane-type soil gas barrier one should ensure they do not become punctured or damaged). For installation information or installer service or maintenance, please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Web site https://www.canada.ca/radon for more information on radon and related mitigation systems.

Table 6 – Radon rough-in system (Level 1b)

Radon system specification: CGSB ___________

Type: Level 1b radon rough-in system for active soil depressurization

Upgrade option: Convert to an active soil depressurization system (Level 3) with addition of an ASD fan.

Description: A radon rough-in system is installed in this building. This system is not operational. The cap on the end of the radon rough-in pipe (outside of the building) needs to remain sealed and in-place until such time that it is converted to an active soil depressurization (with an ASD fan) system (Level 3) by trained individuals that hold a C-NRPP designation for radon mitigation in Canada.

Radon testing: Test the building for radon during the first heating season after occupancy by completing one of the following:

a) Perform a long-term radon test (three-month test) that is approved by C-NRPP or equivalent.

b) Hire a radon measurement provider certified by a program such as C-NRPP or equivalent to perform a long-term radon test (three-month test).

c) Perform a test for a minimum of three months using a digital radon monitor that has passed C-NRPP's performance test (see note 2).

Note 1: An up to date list of C-NRPP approved long-term radon test devices can be found at: https://c-nrpp.ca/approved-radon-measurement-devices/.

Note 2: C-NRPP periodically reports on the performance of digital radon monitors available to Canadian consumers. The most recent report, which includes guidelines for using digital radon monitors, can be found here: https://c-nrpp.ca/wp-content/uploads/2023/10/Digital-Device-Report-Oct-2023.pdf.

Note 3: C-NRPP professionals can only provide long-term radon testing services that make use of C-NRPP approved radon test devices.

The building should be re-tested for radon every five years, or as recommended by Health Canada. Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m^3, take steps to upgrade and activate the radon rough-in system as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Building owner maintenance: Some components of this radon rough-in system require maintenance and monitoring by the building owner or occupant. For example, the caulking on the exterior of the building where the pipe penetrates the exterior wall needs to be periodically inspected and replaced when necessary. For installation information or installer service or maintenance, please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Web site https://www.canada.ca/radon for more information on radon and related mitigation systems.

Table 7 – Passive vertical radon stack (Level 2)

Radon system specification: CGSB ___________

Type: Level 2 full passive vertical radon stack

Upgrade option: Convert to active system with ASD fan.

Description: A passive vertical radon stack system (without an ASD fan) has been designed, installed, and is operating in this building.

Radon testing: This system has been installed to the industry's best practices. However, for various reasons, radon levels may remain elevated. Test the building for radon during the first heating season after occupancy by completing one of the following:

a) Perform a long-term radon test (three-month test) that is approved by C-NRPP or equivalent.

b) Hire a radon measurement provider certified by a program such as C-NRPP or equivalent to perform a long-term radon test (three-month test).

c) Perform a test for a minimum of three months using a digital radon monitor that has passed C-NRPP's performance test (see note 2).

Note 1: An up to date list of C-NRPP approved long-term radon test devices can be found at: https://c-nrpp.ca/approved-radon-measurement-devices/.

Note 2: C-NRPP periodically reports on the performance of digital radon monitors available to Canadian consumers. The most recent report, which includes guidelines for using digital radon monitors, can be found here: https://c-nrpp.ca/wp-content/uploads/2023/10/Digital-Device-Report-Oct-2023.pdf.

Note 3: C-NRPP professionals can only provide long-term radon testing services that make use of C-NRPP approved radon test devices.

The building should be re-tested for radon every five years, or as recommended by Health Canada. Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m^3, take steps to upgrade and activate with an ASD fan the passive vertical radon stack as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Building owner maintenance: Some components of this passive vertical radon stack (including the mesh installed on the end of the pipe) require maintenance and monitoring by the building owner or occupant. For installation information or installer service or maintenance, please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Web site https://www.canada.ca/radon for more information on radon and related mitigation systems.

8.3 Building owner/occupant radon control option system package

The building owner or occupant shall be provided with a documentation package that includes the following:

a) a copy of the appropriate information sheet outlined in 8.2;

b) all manuals for the installed systems, if applicable;

c) all warranty information, if applicable;

d) all radon test data for the property, if applicable.

Note: Here, applicable manuals or warranty information may be related to specific components or products used as part of the construction of the radon control option installed in the new building. For example, products related to the soil gas collection system (and its sub-components), the soil gas barrier and sump covers (if used). Applicable test data could be the result of any short- or long-term radon test conducted in the building prior to occupancy.

9 Inspection

Inspections shall verify if minimum standards and provisions provided in this standard have been met. Items requiring inspection for Level 1a, Level 1b and Level 2 are presented in Annex C (inspection checklists).

Note: The inspection checklists (Annex C) could be used by builders, by installers, or by local building officials.

10 Radon testing devices

Health Canada recommendations for radon mitigation are based on the results of an approved long-term radon test. Long-term tests typically have a duration of three months (or longer) and are conducted in the normal occupancy area of the lowest occupied level of a building.

10.1 Long-term radon measurement devices shall be approved by C-NRPP or equivalent.

10.2 A long-term radon measurement device having a shelf life of more than a year and its testing instructions shall be left for the building owner. Alternatively, arrangements could be made for a radon measurement provider certified by a program, such as C-NRPP or equivalent to deploy a long-term radon test device during the first heating season as recommended by Health Canada.

Note: For more information, please refer to Annex G.

11 Upgrade to a Level 3 system

Installation of Level 1a, Level 1b and Level 2 systems compliant with this standard can be upgraded to the installation of a Level 3 system by following the requirements of standard CAN/CGSB-149.12.

Note 1: For Level 1a systems in completed new buildings, construction of the equivalent of a Level 2 or Level 1b system will be required prior to upgrading to a Level 3 system.

Note 2: Level 3 systems can be installed as part of the construction of a new building. However, their installation is typically performed once construction of a new building is complete.

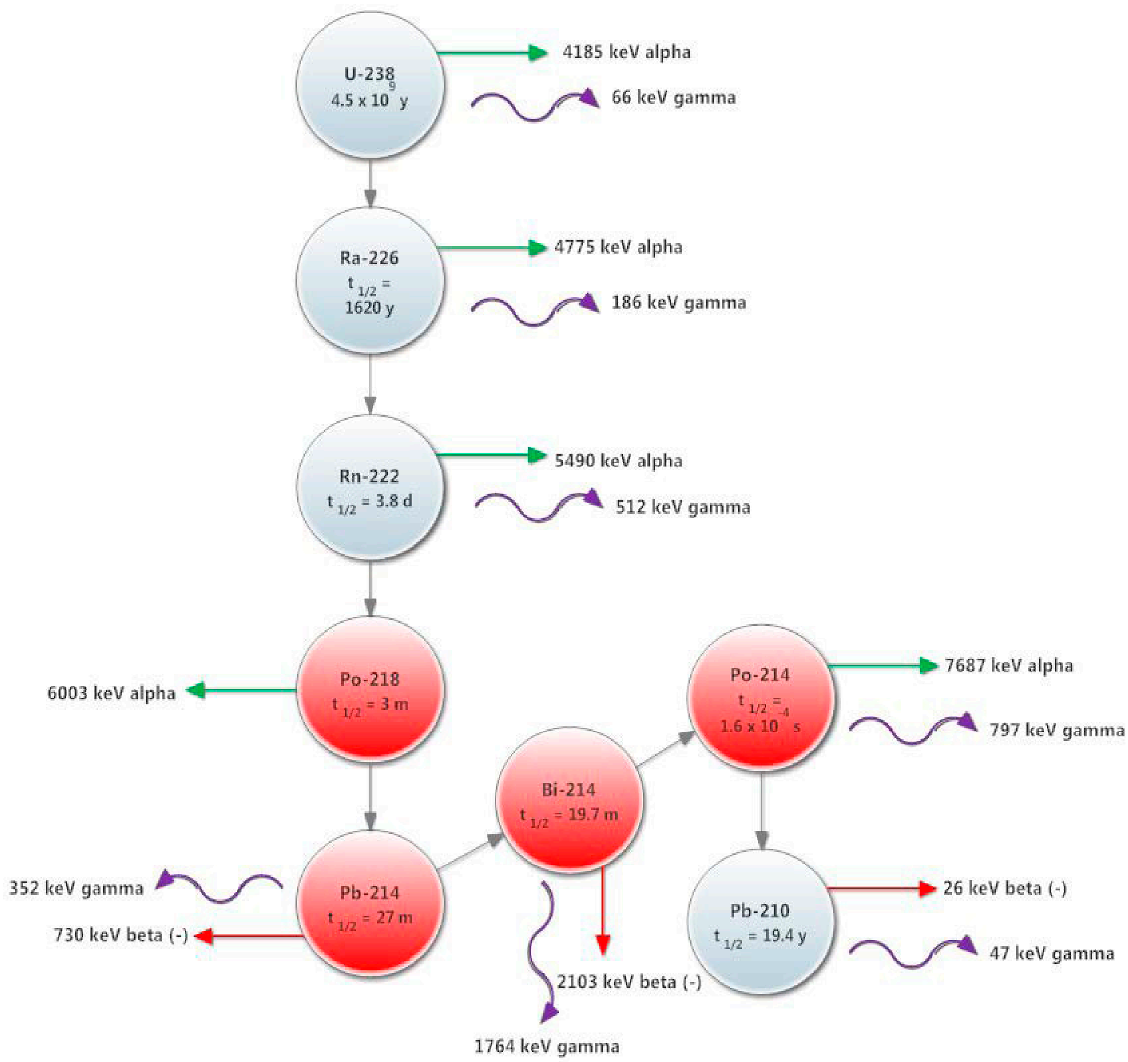
Annex A
(informative)

General information on radon

What is radon?

Uranium is a naturally occurring radioactive element that is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon. Radon is a colourless and odourless gas that is chemically inert, but radioactive (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and groundwater; either escaping into the outdoor air or infiltrating into a building. All soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high concentrations and become a long term health concern. While the health risk from radon exposure below the Canadian (Health Canada) guideline is small, there is no level that is considered risk free.

Figure A.1 – The uranium decay chain



Note: Figure A.1 courtesy of Physics Solutions Inc.

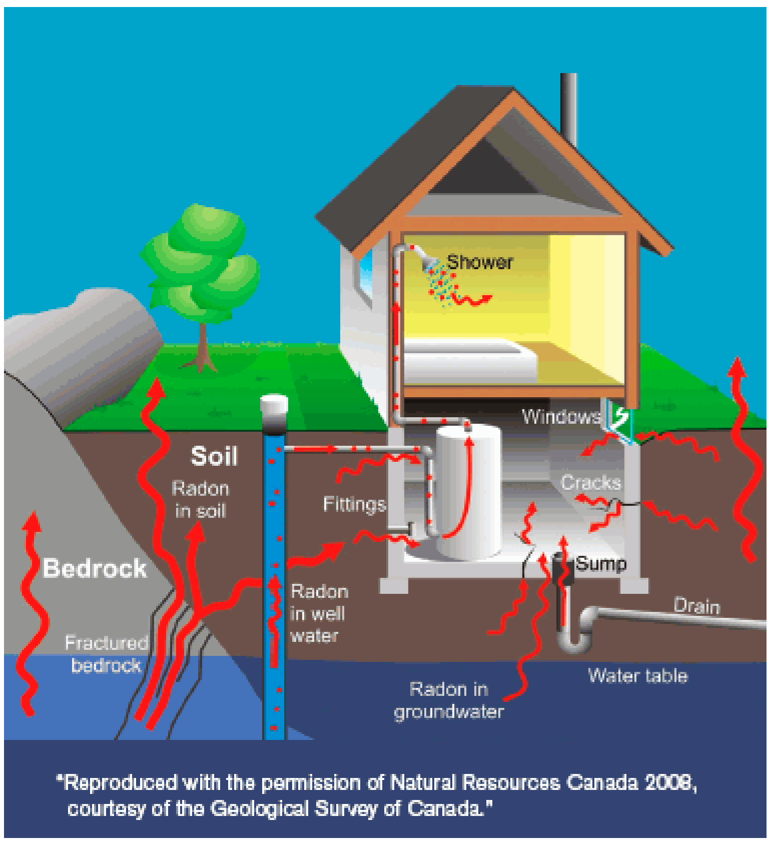
How does radon enter a building?

The air pressure inside a building is usually lower than in the soil surrounding the foundation. This difference in pressure draws in gases, including radon, through openings in the foundation and concrete floor slab where it is in contact with the ground. This includes construction joints, gaps around service pipes and support posts, floor drains and sumps, cracks in foundation walls and in floor slabs, and openings in concrete block walls.

In some areas, radon in the water supply can contribute to the indoor air radon concentration in the building. In such cases, radon dissolves in the water as it travels through rocks and soils. This situation is generally associated with groundwater and thus is more likely to affect well water sources rather than surface waters used for most municipal water supplies. Large volumes of water are used for showers, washing etc., and when heated or agitated, radon, if present in the water, can be released into the air. However, the health risk associated with radon dissolved in water is not from drinking the water, but from breathing the air into which radon has been released.

Potential radon gas entry points are illustrated in Figure A.2.

Figure A.2 – Radon entry points



Although high radon concentrations are associated with some geological formations, the combinations of soil type, building type and foundation type from one location to another mean that radon potential maps are poor indicators of the indoor radon gas concentration in any individual building. Even similar buildings next to each other can have very different average radon concentrations. The only way to know if a building has a high radon level is to measure the radon concentration using a long-term radon test (three-month test) that is approved by C-NRPP or equivalent.

Why is radon gas exposure a health hazard?

The only known current health risk associated with exposure to radon is an increased risk of developing lung cancer. The risk of developing lung cancer depends on the following:

a) the smoking habits of the exposed person;

b) the average radon concentration in the building;

c) the length of time a person is exposed.

Health Canada estimates a non-smoker exposed to elevated levels (i.e., 800 Bq/m^3) of radon over a lifetime has a 1 in 20 chance of developing lung cancer. The combined effects of radon exposure and smoking tobacco significantly increase the risk of lung cancer (tobacco leaves also uptake radioactive Po-210 from the soil). If a smoker is exposed to the same elevated level of radon over a lifetime, the risk increases to a 1 in 3 chance.

When a radon atom decays, it emits an alpha particle and produces new elements, called “radon progeny”. Unlike radon, the radon progeny (also referred to as radon decay products or radon daughters) are solids.

When alpha particles hit an object, such as a cell, their energies are transferred to that object, resulting in damage. Human skin is thick enough that the alpha particles cannot penetrate to more vulnerable tissues beneath, but if you breathe in radon or its progeny, the alpha particles they emit can damage unprotected and sensitive bronchial and lung tissues, which can then lead to lung cancer.

Originally, the estimate of lung cancer risk from radon exposure was based on exposures to high concentrations found in uranium mines, and the risk from lower concentrations typically found in buildings was uncertain. However, recent residential studies have confirmed that even exposure to the lower radon concentrations found in buildings carries a lung cancer risk[10, 11]. The time between exposure and the onset of the disease is usually many years (the average age of onset for lung cancer is age 60). Unlike smoking, besides lung cancer, exposure to radon does not cause other diseases or respiratory conditions nor does it produce symptoms such as coughing or headaches.

Radon guideline

Beginning in 2005, Health Canada collaborated with the Federal Provincial Territorial Radiation Protection Committee (FPTRPC) to review the health risk from exposure to radon. The risk assessment was based on new scientific information and was the subject of a broad public consultation. Using the risk assessment and feedback obtained from the public consultation, the Government of Canada updated its guideline for exposure to radon in indoor air in 2007[1]. This updated guideline provides advice that is more broadly applicable and more protective than the previous FPTRPC guideline.

The current Government of Canada guideline for exposure to radon in indoor air is as follows:

- Remedial measures should be undertaken in a building whenever the average annual radon concentration exceeds 200 Bq/m^3 in the normal occupancy area.
- The higher the radon concentration, the sooner remedial measures should be undertaken.
- When remedial action is taken, the radon level should be reduced to a level or concentration as low as practicable.
- The construction of new buildings should employ techniques that will minimize radon entry and facilitate post-construction radon removal should this subsequently prove necessary.

For more information about radon and the guideline, visit the Health Canada Web site at https://www.canada.ca/radon.

Annex B
(informative)

Radon control systems: Information for builders and building officials

The below information *What is radon?, What are the health effects of radon?,* and *How can radon get into a building?* are based on content from *Reducing Radon in Existing Homes: A Canadian Guide for Professional Contractors*, Health Canada, 2010[9].

What is radon?

Uranium is a naturally occurring radioactive element that is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon. Radon is a colourless and odourless gas that is chemically inert, but radioactive (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and groundwater; either escaping into the outdoor air or infiltrating into a building. All soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high concentrations and become a long term health concern. While the health risk from radon exposure below the Canadian Guideline is small, there is no level that is considered risk free.

What are the health effects of radon?

Exposure to high levels of radon in indoor air results in an increased risk of developing lung cancer. The risk of lung cancer depends on the level of radon, how long a person is exposed to those levels, and their smoking habits.

How can radon get into a building?

The air pressure inside a building is usually lower than in the soil surrounding the foundation. This difference in pressure (also known as the stack effect) draws air and other gases, including radon, from the soil into the building.

Radon can enter a building any place it finds an opening where the building is in contact with the soil: cracks in foundation walls and in floor slabs, construction joints, gaps around service pipes, support posts, window casements, floor drains, sumps or cavities inside walls.

Radon mitigation

Radon levels vary from building to building depending on lot conditions and construction, and there is currently no way to determine the radon concentrations within a building before construction. Testing is required after construction to determine radon concentrations, and mitigation efforts may be required should radon concentrations be found to be above the Canadian guideline of 200 Bq/m^3. During construction, steps should be taken to minimize radon entry and to install control options that facilitate post-construction radon removal should this subsequently prove necessary. There are three levels of radon control system installation that can be installed, as outlined below:

Level 1: Radon rough-in system for ASD provides minimum protection and provides provisions for a radon rough-in and soil gas barrier that reduces the convection and diffusion of radon from the ground into the building. Level 1 is not a complete radon control system, but allows for easier conversion to one in the future, should it become necessary. There are two options for a radon rough-in which are defined based on where the capped pipe end terminates:

- Level 1a: Rough-in with sealed capped end located in the building interior.
- Level 1b: Rough-in where piping penetrates rim-joist or sidewall of the building to the outdoors, where its end is capped and sealed.

Level 2: Passive vertical radon stack (includes Level 1a PLUS a stack) provides moderate protection and includes all provisions of Level 1a, with the addition of extending the pipe stub to create a full, passive (without an ASD fan) vertical radon stack system that runs upwards through the inside of the building and vents above the roof to the outdoors. The stack passes through heated portions of the building or is insulated in unconditioned portions. Level 2 is a complete passive radon control system. Research has demonstrated Level 2 systems have reduced indoor radon gas concentrations by 40 to 90%[2-8].

Level 3: Active soil depressurization system (includes [Levels 1a AND 2 PLUS an ASD fan] OR [Level 1b PLUS an ASD fan]) (CAN/CGSB-149.12) provides the highest level of protection available and includes all provisions from either Levels 1a and 2, or Level 1b with the addition of an ASD fan to create an ASD system. Level 3 is a complete radon control system. For ASD systems, an ASD fan depressurizes the gas permeable layer leading to greater radon reductions than the passive system (Level 2) described previously. Level 3 systems often reduce high radon levels by 90% or more. Details on the upgrade of a Level 1b and Level 2 system to a Level 3 system are provided in CAN/CGSB-149.12 standard. Level 3 systems can be built as part of the construction of new buildings or the mitigation of existing buildings.

Visit the Health Canada Web site at https://www.canada.ca/radon for more information on radon and related mitigation systems.

Annex C
(informative)

Inspection checklists

The following checklists are examples of the minimum standards and provisions that should be used for inspection of a completed Level 1a, Level 1b or Level 2 system (see section 9).

Table C.1 – Level 1a inspection checklist

Level 1a radon rough-in system – Inspection checklist			
OK	**NIC***	**NIC = Not in compliance*	
Soil gas collection system (7.1.1)			
☐	☐	Soil gas collection system	7.1.1.1 through 7.1.1.3
☐	☐	Gas permeable layer	7.1.1.4
☐	☐	Gas permeable layer – permitted material	7.1.1.4.2
☐	☐	Soil gas collector	7.1.1.5
☐	☐	Soil gas collector – permitted pipe	7.1.1.5.1
☐	☐	Soil gas collector – proper installation	7.1.1.5.2 through 7.1.1.5.9
☐	☐	Suction point for soil gas collection system	7.1.1.6
Radon rough-in pipe (7.1.2.2) – Level 1a			
☐	☐	Permitted pipe	7.1.2.2.1
☐	☐	Connection to soil gas collection system via suction point	7.1.2.2.2, 7.1.2.2.4
☐	☐	Vertical extension of rough-in pipe no less than 300 mm	7.1.2.2.3
☐	☐	Rough-in pipe cap (inside)	7.1.2.4.1
Piping (7.1.3)			
☐	☐	Permitted pipe, installation, solvent cement (where applicable), and priming materials	7.1.3.1, 7.1.3.2
☐	☐	At least 1% slope	7.1.3.1.6
Sealing the soil gas collection system (7.1.4)			
☐	☐	Soil gas barrier installation	7.1.4.1 through 7.1.4.4
☐	☐	Slab and foundation seal	7.1.4.6.6 through 7.1.4.6.10
Sealing entry points in the slab (7.1.5)			
☐	☐	Sump pits	7.1.5.1
☐	☐	Drains	7.1.5.2
☐	☐	Openings	7.1.5.3
☐	☐	Other penetrations	7.1.5.4

Level 1a radon rough-in system – Inspection checklist			
OK	**NIC***	**NIC = Not in compliance*	
Sealing entry points in foundation (7.1.6)			
☐	☐	Hollow masonry units	7.1.6.1
☐	☐	Other penetrations (e.g., bathtub or shower cut-outs)	7.1.6.2
Labelling (8.1) and information sheet (8.2)			
☐	☐	Soil gas barrier	8.1.5.1.1
☐	☐	Radon rough-in pipe (Level 1a)	8.1.5.2
☐	☐	Sump	8.1.5.3
☐	☐	Electrical panel and receptacle	8.1.7
☐	☐	Radon maintenance and information label	8.2 (Table 5)
Radon testing device (10)			
☐	☐	Device provided to building owner	10

Table C.2 – Level 1b inspection checklist

Level 1b radon rough-in system – Inspection checklist			
OK	**NIC***	**NIC = Not in compliance*	
Soil gas collection system (7.1.1)			
☐	☐	Soil gas collection system	7.1.1.1 through 7.1.1.3
☐	☐	Gas permeable layer	7.1.1.4
☐	☐	Gas permeable layer – permitted material	7.1.1.4.2
☐	☐	Soil gas collector	7.1.1.5
☐	☐	Soil gas collector – permitted pipe	7.1.1.5.1
☐	☐	Soil gas collector – proper installation	7.1.1.5.2 through 7.1.1.5.9
☐	☐	Suction point for soil gas collection system	7.1.1.6
Radon rough-in pipe (7.1.2.2) – Level 1a requirements for Level 1b			
☐	☐	Permitted pipe	7.1.2.2.1
☐	☐	Connection to soil gas collection system via suction point	7.1.2.2.2, 7.1.2.2.4
Radon rough-in pipe (7.1.2.3) – Level 1b			
☐	☐	Permitted pipe	7.1.2.3.1
☐	☐	Extension through rim-joist or sidewall at right-angle	7.1.2.3.2
☐	☐	Penetration through rim-joist or sidewall watertight	7.1.2.3.3
☐	☐	Exhaust clearances outside	7.1.2.3.4.2
☐	☐	Provisions for future addition of an ASD fan	7.1.2.3.4.3
☐	☐	Rough-in pipe cap (outside)	7.1.2.4.2

Level 1b radon rough-in system – Inspection checklist			
OK	**NIC***	**NIC = Not in compliance*	
Piping (7.1.3)			
☐	☐	Permitted pipe, installation, solvent cement (where applicable), and priming materials	7.1.3.1, 7.1.3.2
☐	☐	At least 1% slope	7.1.3.1.6
Sealing the soil gas collection system (7.1.4)			
☐	☐	Soil gas barrier installation	7.1.4.1 through 7.1.4.4
☐	☐	Slab and foundation seal	7.1.4.6.6 through 7.1.4.6.10
Sealing entry points in the slab (7.1.5)			
☐	☐	Sump pits	7.1.5.1
☐	☐	Drains	7.1.5.2
☐	☐	Openings	7.1.5.3
☐	☐	Other penetrations	7.1.5.4
Sealing entry points in foundation (7.1.6)			
☐	☐	Hollow masonry units	7.1.6.1
☐	☐	Other penetrations (e.g., bathtub or shower cut-outs)	7.1.6.2
Labelling (8.1) and information sheet (8.2)			
☐	☐	Soil gas barrier	8.1.5.1.1
☐	☐	Radon rough-in pipe (Level 1b)	8.1.5.2
☐	☐	Sump	8.1.5.3
☐	☐	Electrical panel and receptacle	8.1.7
☐	☐	Radon maintenance and information label	8.2 (Table 6)
Radon testing device (10)			
☐	☐	Device provided to building owner	10

Table C.3 – Level 2 inspection checklist

Level 2 passive vertical radon stack system – Inspection checklist			
OK	**NIC***	**NIC = Not in compliance*	
Includes Level 1a – requirement for Level (2) system			
☐	☐	Includes Level 1a (see Level 1a checklist, excluding rough-in pipe cap – 7.1.2.4.1)	7.1
Pipe and fittings (7.2.3)			
☐	☐	Pipe insulated where passing through unconditioned space	7.2.2.4
☐	☐	Pipe length above roof-line compliant with 2.5% outdoor winter design temperature	7.2.2.5, Table 3
☐	☐	Permitted pipe	7.2.3.1
☐	☐	Tested for leaks	7.2.3.2
System termination (7.2.4)			
☐	☐	Permitted distances and other requirements	7.2.4.1 through 7.2.4.5
Future system activation provisions (7.2.5)			
☐	☐	Space for an ASD fan	7.2.5.1
☐	☐	Boxed receptacle outlet	7.2.5.2
☐	☐	Access	7.2.5.3
Labelling (8.1) and information sheet (8.2)			
☐	☐	Passive vertical radon stack	8.1.6.1 through 8.1.6.2
☐	☐	Sump	8.1.5.3
☐	☐	Electrical panel and receptacle	8.1.7
☐	☐	Radon maintenance and information label	8.2 (Table 7)
Radon testing device			
☐	☐	Device provided to building owner	10

Annex D
(informative)

Radon from water and construction materials

This National Standard of Canada describes reducing radon in new construction where the radon in air originates in the soil surrounding and beneath the building. However, radon can enter a building via two other mechanisms primarily.

Radon can be dissolved in well water that enters the building from the distribution piping. When a faucet is opened, radon dissolved in the water will outgas into the air. This can happen, for example, during periods when occupants are showering, washing dishes, or doing laundry. Generally speaking, this radon outgassing is a very small contributor to indoor radon levels.

Radon concentrations in municipally treated water systems are usually extremely low as a result of a combination of water treatment methods and delays in water treatment processing and distribution. Radon concentrations in well water can be significant depending on the source, but again, it requires extremely high radon concentrations dissolved in well water to appreciably impact indoor radon gas concentrations. A general rule of thumb used in the radon profession is that one requires roughly 10,000 times the radon in water concentrations per m^3 of water (i.e., 2,000,000 Bq/m^3 radon in water) before radon in water is likely to impact the indoor radon gas concentrations significantly. Radon concentrations in water this high are a rare occurrence, but can happen occasionally in private or community wells. If the air of a building supplied with groundwater tests above 200 Bq/m^3, testing for radon levels in water should be considered. Radon in water test kits are commercially available. Radon mitigation from the soil should be performed first, as it is usually the main contributor to high indoor radon levels. Depending on the results of the post-mitigation radon test for indoor radon gas concentrations, it may be necessary to also mitigate radon from water in order to reduce radon gas levels inside a building.

Well water systems having high radon concentrations can be treated in several ways in order to remove radon from the water before it can outgas into a home. The main techniques used today are aeration (to displace radon) or treatment with granulated activated carbon (to trap radon). Both techniques require consideration of the overall composition of the water source to prevent clogging or fouling of these treatment systems, and the concentrations of radon in the water. Aeration is the preferred treatment technique for removing high concentrations of radon from well water.

Treatment with activated carbon requires consideration of long-term storage and disposal of the cartridges as gamma emitting radioactive radon decay products may build up on the filter. This may require shielding of the cartridge, or mounting the cartridge outdoors or in an uninhabited part of the basement to reduce exposure of occupants to gamma radiation. Depending on the concentration of radon in the water and the length of time the granulated activated carbon filter is used, spent cartridges may require specialized hazardous waste disposal.

The other potential source of radon entering a building can originate in the materials of construction, depending on the concentration of radium-226 (the immediate parent of radon-222) present in the material. Radon can emanate from materials such as concrete, drywall, tiles, or granite countertops. Again, the contribution made by materials of construction to indoor radon gas concentrations in Canada is generally very small. Health Canada performed a study of radon emanation from a number of the most popular tiles and granite countertops sold into Canada and found that these were unlikely to contribute significantly to indoor radon levels[12]. Health Canada also performed a small study on emanation of radon from aggregate samples from various Canadian sources and found that these generally would be small contributors to indoor radon gas concentrations[13].

Annex E
(informative)

Radon control system information for building owners

What is radon?

Uranium is a naturally occurring radioactive element that is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon. Radon is a colourless and odourless inert gas that is chemically inert, but radioactive (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and groundwater; either escaping into the outdoor air or infiltrating into a building. All soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high concentrations and become a long term health concern.

What are the health effects of radon?

Exposure to high levels of radon in indoor air results in an increased risk of developing lung cancer. The risk of cancer depends on the level of radon and how long a person is exposed to those levels.

How can radon get into my building?

The air pressure inside a building is usually lower than in the soil under the building surrounding the foundation. This difference in pressure (also known as the stack effect) draws air and other gases, including radon, from the soil into your building.

Radon can enter a building any place it finds an opening where the building contacts the soil: cracks in foundation walls and in floor slabs, construction joints, gaps around service pipes, support posts, window casements, floor drains, sumps or cavities inside walls.

Do I have a radon control system?

Yes, if your building has been constructed with the following:

a) Radon rough-in for ASD system: visually identifiable as a capped and labelled pipe stub above the finished floor of the lowest level.

b) Extended radon rough-in system: visually identifiable as a pipe run between the finished floor of the lowest level and the outside of the building where it penetrates through a sidewall. The portion of the pipe run inside the building is labelled. The portion of the pipe outside the building is capped and labelled.

c) Passive (soil depressurization) stack: visually identifiable as a vertical pipe run between the finished floor of the lowest level and the outside of the building where it penetrates through the roof or gable. The portion of the pipe run inside the building is labelled. Portions of the pipe run located in unconditioned spaces are insulated.

Level 1 — Rough-in for ASD
Level 1 consists of a rough-in stub for a radon control system. A pipe extends into a soil gas collection plenum in the gas permeable layer (often granular material) under the foundation floor, which acts as an entry point for radon and other soil gases to a radon control system. The pipe then terminates just above the slab and is capped. This system is only a rough-in and forms the basis for either a Level 2 (passive) or Level 3 (active) mitigation system. Level 1 also includes a soil gas barrier installed underneath the concrete slab which is sealed to the foundation walls or footings to minimize radon ingress, in addition to sealing the expansion joint around the perimeter of the foundation between the wall and the concrete slab.

It is also important that the continuity of the air barrier be maintained in the basement, including sump pit covers, floor drains, other slab service pipe penetrations, and by caulking any cracks and joints in the foundation.

Level 2 ─ Full passive vertical radon stack
Level 2 extends the pipe from Level 1 up through the interior of the building vertically to terminate outdoors. There are provisions for the termination of the pipe to ensure re-entrainment of radon does not occur. The system relies on naturally occurring pressure differentials (generated by the stack effect) to draw radon gas from under the foundation floor up through the building and out through the roof.

Level 3 ─ Full active soil depressurization system
Level 3 uses the pipe from Level 1b or Level 2 and includes an ASD fan. The system relies on the ASD fan to induce a pressure difference to exhaust soil gases and radon gas from under the slab. ASD fans run continuously, and a system pressure monitor is installed for the monitoring of the system. This method has been shown to be highly effective at reducing radon gas concentrations in a building.

Is there system maintenance?

Your radon system has been labelled in various locations, such as pipe, air barriers, and electrical panels and ASD fans, if applicable. DO NOT ALTER OR DISCONNECT any of these components.

Pipe
Inspect all exposed piping for damage at least once per year.

Membranes
The plastic membrane used in crawl spaces, if applicable, should be inspected at least once per year for tears, cuts, or leaks in its seals, and any damage should be repaired as soon as is reasonably possible. The radon control system can have its performance reduced if damage to the membrane results in air leakage. Whenever there is an object resting on the membrane, check to ensure the membrane is protected from damage.

Sump pit
For sump pits, if applicable, an active (fan driven) radon control system can have its performance reduced if the sump pit cover is not tightly sealed. An unsealed sump cover may result in conditioned air from inside the building being removed instead of radon soil gas only being removed from beneath the slab as intended, which can in turn increase the risk of depressurizing the building. The sump cover’s condition should be inspected at least once per year to ensure the integrity of its seals. This includes checking if gaskets are in good condition, and mechanical fasteners are installed to hold the cover in place. When repairing or replacing caulking, a removable type of caulk should always be used to seal the cover. If the sump basin requires maintenance, restore it to the original condition immediately after completing the work.

Foundation
Foundation settling, renovations (including openings associated with plumbing), or additions to your building can alter the radon concentrations in your building. You should test your building for radon after any of the above.

Water traps (floor drains)
Water traps or other devices should be fitted for drains to control sewer/soil-gas entry. Where water traps are installed, they should be filled at least once per month to replace evaporated water.

Continuous radon monitors (professional-grade)
Where certified professional-grade continuous radon monitors are used as part of a maintenance inspection to ensure the system is maintaining low radon levels in a building, they should be sent for recalibration every two years, or as specified by the manufacturer, at least one week before the calibration certificate expires.

System pressure gauge
Active radon control systems (Level 3) have a system pressure gauge that indicates the pressure in the piping system created by the ASD fan. The initial pressure should have been marked by the system installer. You should

regularly check the gauge at least once per month to ensure the system is operating properly. If the gauge indicates a substantial change from the original marked pressure, or if it reads zero pressure, your radon control system may not be working properly, and you should call for service. This gauge measures suction pressure in inches water column, it does not measure radon.

ASD fans

ASD fans for active systems should never be turned off; if turned off, the system will no longer function as intended. ASD fan replacement will vary depending on the location of the building and where the ASD fan is installed. For example, ASD fans installed in basements are typically easier to replace than those installed in attics. ASD fan replacement should be completed by a trained individual holding C-NRPP designation. Fan options and pricing can vary.

Should I test for radon?

Your building has not yet been tested for radon. Health Canada recommends that buildings be tested for a minimum of three months, ideally between October and April. You should test your building during the first heating season of occupancy, and subsequently every five years. Testing is easy and inexpensive.

You should have received a long-term radon test kit approved by C-NRPP or equivalent at the time of occupancy. Radon testing can be easily carried out by using special detectors available from commercial businesses, building improvement stores, some municipalities, and many provincial lung associations. These devices are simply placed in your building, exposed to indoor air for a specified time period and then returned to the company to be analyzed. Other businesses will send a trained technician to your building to do the testing for you. For a list of service providers, you may also contact the C-NRPP at 1-800-269-4174 or Health Canada at:

Radiation Health Assessment Division – Health Canada
775 Brookfield Road, A.L. 6302D
Ottawa, Ontario K1A 1C1
1-833-723-6600
radon@hc-sc.gc.ca

Where can I learn more?

Visit the Health Canada Web site https://www.canada.ca/radon for more information on radon and testing your building.

Annex F
(informative)

Expected radon reduction

A building with high radon levels can have the radon levels reduced most significantly by using some variant of the ASD technique, whether that be by Sub-Slab Depressurization (SSD), sub-membrane depressurization or a combination thereof. The percentage radon reduction achieved by active SSD, for instance, is typically around 90% when high pre-mitigation radon levels are present but can be as high as 99% in some cases.

Therefore, in most new buildings, it is possible to reduce radon levels to below the Canadian radon guideline of 200 Bq/m^3, and in fact, in many instances, one should be able to reduce radon levels to below the WHO reference value of 100 Bq/m^3. However, since indoor radon concentrations for newly constructed buildings cannot be predicted, installing a system that uses the active soil depressurization technique cannot guarantee that concentrations below the Canadian guideline of 200 Bq/m^3[1] will be achieved.

The intent will be to reduce radon levels to as low as reasonably achievable (ALARA). The ALARA principle takes into account social and economic factors that can include affordability and technical practicalities. Buildings with very high radon in air levels (for example >10,000 Bq/m^3), may require more effort and expense to reduce radon levels to below the Canadian radon guideline of 200 Bq/m^3.

Annex G
(informative)

Radon testing devices

Radon testing should be conducted in all new buildings once occupied. For buildings with a Level 1 system, this is required to determine if a Level 3 system is necessary. For buildings with a Level 2 or Level 3 system, this is required to ensure the systems are effective and to determine if additional steps are necessary to achieve lower radon levels.

Radon levels in a building can vary significantly over time in the short term. They can rise and fall from one hour or day to the next and seasonally. For this reason, measurements taken over a longer period of time are more accurate. Health Canada recommend long-term radon tests, conducted for a minimum of three months during the fall or winter (i.e., October through April) and that the detector be placed in the lowest level of the building where occupants spend a minimum of 4 hours per day (for example, a finished basement). A three-month test provides a good indication of a person's annual average exposure and should be used to determine if a building's radon concentration exceeds the Canadian radon guideline level of 200 Bq/m^3. Testing can be achieved through a do-it-yourself kit or by hiring a professional. Information on both can be found through the Take Action on Radon website: https://takeactiononradon.ca/test-for-radon/radon-test-kits/.

The long term radon detectors that are most commonly used in Canada are Alpha Track Detectors (ATD) and Electret Ion Chambers (EIC). For a list of C-NRPP approved long-term measurement devices, please go to http://c-nrpp.ca/approved-radon-measurement-devices.

Links to online retailers of radon detectors can be found through the Take Action on Radon Web site: https://takeactiononradon.ca/test-for-radon/radon-test-kits/#buykit.

Consumer-grade digital radon monitors for short and long-term testing are also available in the market. C-NRPP periodically reports on the performance of specific digital radon monitors available to Canadian consumers. The most recent report, which includes guidelines for using digital radon monitors, can be found here: https://c-nrpp.ca/wp-content/uploads/2023/10/Digital-Device-Report-Oct-2023.pdf. These devices may be an option for building owners/occupants.

Health Canada continues to closely monitor digital radon detectors on the market and takes action to protect Canadians. On September 7th, 2022, Health Canada issued an alert and proceeded to a consumer product recall on September 13th, 2022 about such devices. They are published on the following page:

Recalls, advisories and safety alerts – https://recalls-rappels.canada.ca/en.

Also see: https://iopscience.iop.org/article/10.1088/1361-6498/ab96d6.

More information on radon measurement can be found in Health Canada's radon measurement guides for homes: https://www.canada.ca/en/health-canada/services/publications/health-risks-safety/guide-radon-measurements-residential-dwellings.html and public buildings: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/radiation/guide-radon-measurements-public-buildings-schools-hospitals-care-facilities-detention-centres.html.

Annex H
(informative)

Terms, definitions and conversions

Table H.1 — Select system international (SI) prefixes

Prefix	Name	Units
p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}

Table H.2 — Terms

Term	Definition	Conversion
Bq	Becquerel – an SI measure of the rate at which radiation is emitted by a radioactive source. It is expressed as the number of radioactive decays per second (dps).	1 Bq = 1 dps = 27 pCi
Bq/m^3	Becquerels per cubic metre – an SI measure of radon activity concentration in a cubic metre volume of air.	1 Bq/m^3 = 0.027 pCi/L
Ci	Curie – a conventional (non-SI) measure of the rate at which radiation is emitted by a radioactive source. Originally defined as the decay rate of [1 gram of] Ra, i.e., approximately 3.7 x 10^{10} decays per second (dps).	1 Ci = 3.7 x 10^{10} dps = 3.7 10^{10} Bq.
eV	Electron volt – the energy required to raise an electron through a potential difference of 1 volt.	Not applicable
mil	One thousandth of an inch. Also known as ‘thou’.	1 mil = 0.001 in. = 0.025 mm
In WC	Inches (of) Water Column – a conventional measure of pressure, 1 in WC = 249 Pa. Also written as Water Column [inch].	1 In WC = 249 Pa
Pa	Pascal – an SI measure of pressure.	1 Pa = 0.004 In WC
pCi	Picocurie – 10^{-12} curies or 0.037 Becquerels or 0.037 decays per second.	1 pCi = 0.037 Bq
pCi/L	picocuries per litre – a non-SI measure of radon activity concentration in one litre.	1 pCi/L = 37 Bq/m^3

Annex I
(informative)

Other new construction considerations

In new construction there are several possible features which may not be common but that bear special consideration from a radon ingress standpoint.

The following features in this Annex bear special mention.

Sump pit depressurization – Where sump pits are used as the inlet of an active or passive soil depressurization system in new construction, special design considerations should be addressed. These areas collect water and are used to divert this water away from the foundation or basement area using pumps and often auxiliary back-up pumps. Installing an ASD inlet in such a location may result in challenges with servicing or accessing the sump pit area for its main purpose of water removal. If sump pit lids are not well sealed this may result in radon ingress and may also result in a significant reduction in the efficiency of an active (fan driven) or passive soil depressurization system since a leaking sump pit cover will result in conditioned air being evacuated from within the building by an active system instead of the intended goal of only removing soil gases from beneath the slab. Withdrawing large amounts of air from within the building can in turn increase the risk of depressurizing the building. In addition, proper decoupling of the pipe connection has to be considered to minimize the noise generated by the ASD fan transmitted through the radon pipe to the sump pit cover and to provide for convenient servicing of the sump area.

Drain tile depressurization – Exterior drain tiles that are open to daylight should not be connected to an ASD system. This can interfere with how the drainage system around the perimeter of a building is intended to perform. During freeze-up periods, this could also result in an ASD system which functions much less efficiently or not at all if pipes are either filled with water or with ice.

Permanent wood foundations – Since permanent wood foundations may be difficult to seal, installation of an ASD system in a building with such a foundation requires that the perimeter interface be well sealed. If the base of the foundation is not well sealed and the location of the ASD inlet is placed close to a foundation wall, then the ASD system may be drawing outdoor air into it rather than removing radon containing soil gas from beneath the basement slab area as intended.

Guidance for permanent wood foundations can be found in the document *Permanent Wood Foundations*, 2016, from the Canadian Wood Council. Excerpts are shown below in figures I.1 – I.4 with permission of the Canadian Wood Council.

Figure I.1 – Soil gas barrier laid beneath suspended wood floor

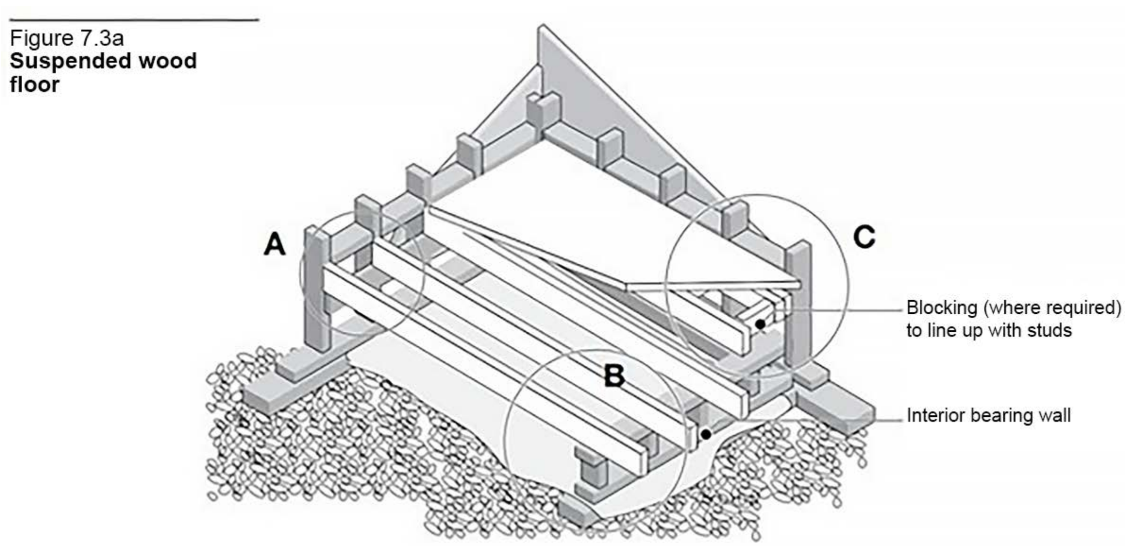


Figure I.2 – Soil gas barrier (labelled as "Polyethylene ground cover") laid over wood footing beneath suspended wood floor

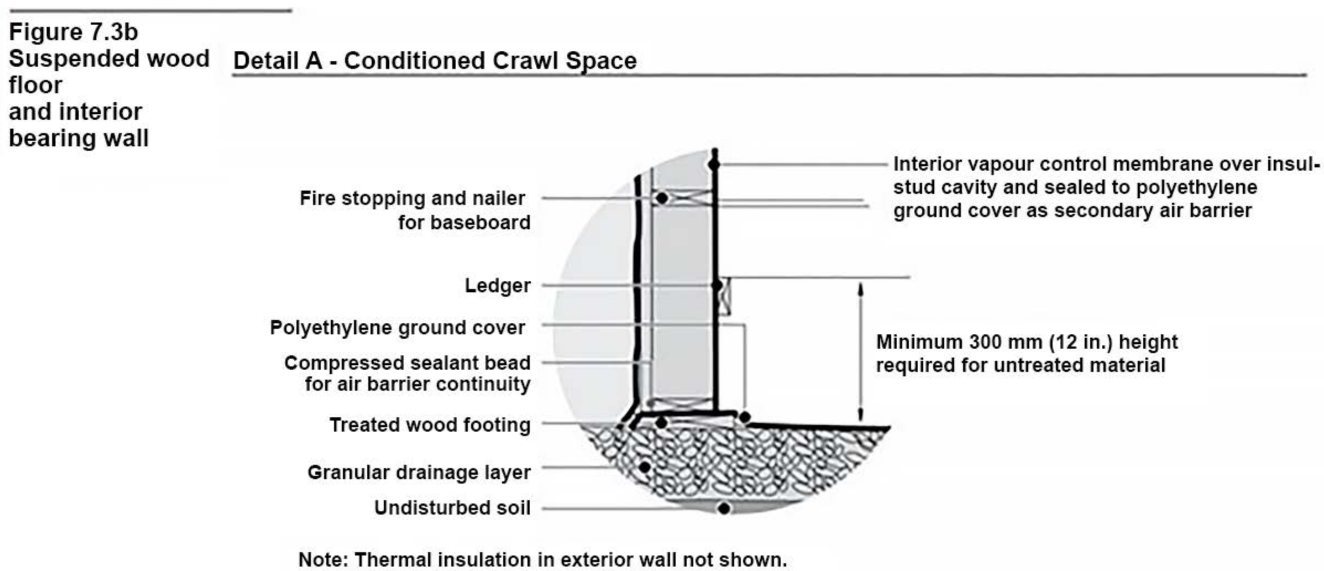


Figure I.3 – Soil gas barrier (labelled as "Polyethylene ground cover") laid over wood footing beneath a suspended wood floor at a location beneath an interior wall

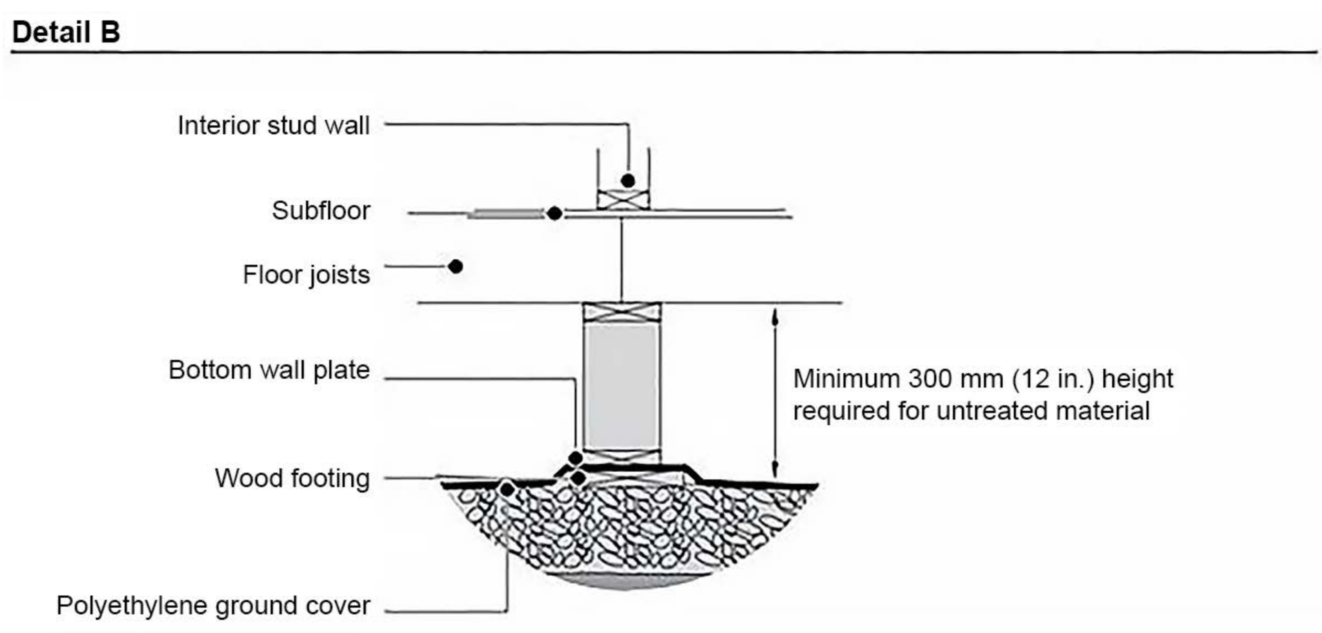
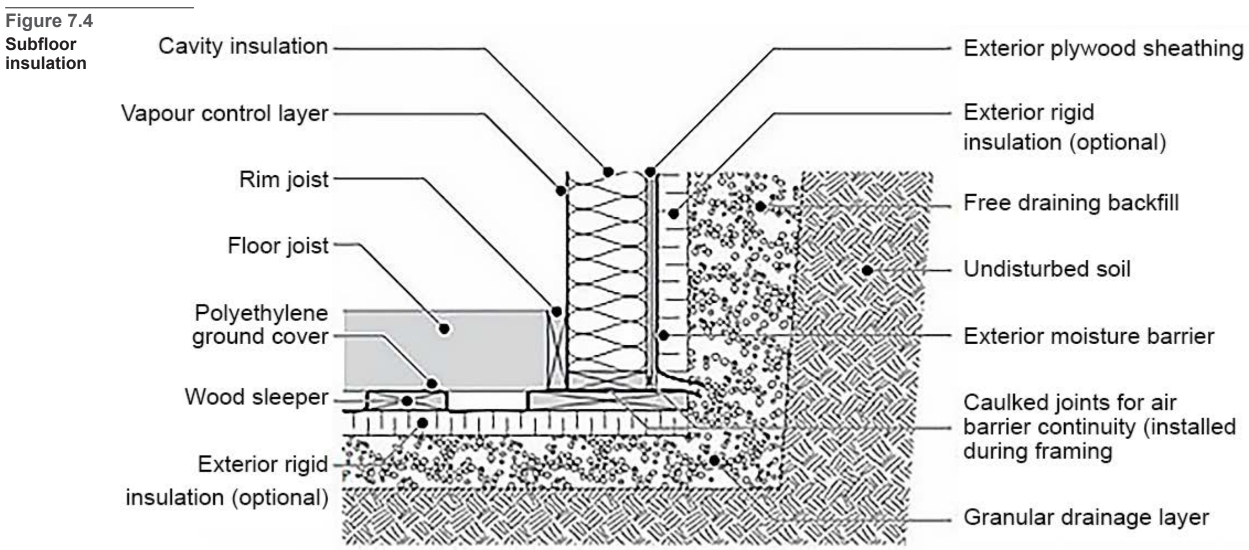


Figure I.4 – Soil gas barrier (labelled as “Polyethylene ground cover”) laid over wood sleeper and footing



Block wall foundation construction – Block wall construction presents special challenges potentially in radon removal. Since block walls are typically hollow, they present additional entry flow paths for radon containing soil gas. As a result, it is recommended that top and bottom courses of block walls be solid block construction to reduce the odds of radon entry through the walls. It is also important that the mortar joints between blocks are well-sealed in order to minimize radon ingress.

Bibliography

[1] Health Canada. 2007. *Indoor air quality guideline for radon*. Canada Gazette Part I, June 9th, 2007. Accessed November 25th, 2022: https://gazette.gc.ca/rp-pr/p1/2007/2007-06-09/pdf/g1-14123.pdf.

[2] Zhou, L., *et al.*, 2021. *Passive soil depressurization in Canadian homes for radon control*. Building and Environment. 188:107487. DOI: https://doi.org/10.1016/j.buildenv.2020.107487.

[3] Gaskin, J., *et al.*, 2022. *Regional cost effectiveness analyses for increasing radon protection strategies in housing in Canada*. J. Environmental Radioactivity. 240. DOI: https://doi.org/10.1016/j.jenvrad.2021.106752.

[4] Monahan, E., *et al.*, 2022. *The effectiveness of passive sumps and static cowls in reducing radon levels in new build Irish dwellings*. J. Environmental Radioactivity. 248: 106866. DOI: https://doi.org/10.1016/j.jenvrad.2022.106866.

[5] Rogoza, D., *et al.*, 2015. *A Comparison of Three Radon Systems in British Columbia Homes: Conclusions and Recommendations for the British Columbia Building Code*. Available from: https://bclung.ca/health-air-quality/radon-and-lung-health/radonaware-outputs or direct link: https://bclung.ca/sites/default/files/A%20Comparison%20of%20Three%20Radon%20Systems%20in%20BC%20Homes.pdf.

[6] Finne, I.E., *et al.*, 2019. *Signifcant reduction in indoor radon in newly built houses. J. Environmental Radioactivity*. 196 :259-263. DOI: https://doi.org/10.1016/j.jenvrad.2018.01.013.

[7] Arvela, H., *et al.*, 2012. *Radon prevention in new construction in Finland : a nationwide sample survey in 2009*. Radiation Protection Dosimetry. 148(4) :465-474. DOI: https://doi.org/10.1093/rpd/ncr192.

[8] Gaskin J., *et al.*, 2022. Residential radon mitigation using passive soil depressurization in Quebec, Canada. Proceedings of the Indoor Air 2022 Conference, Kuopio, June 12-16. Conference Proceedings - International Society of Indoor Air Quality and Climate (https://www.isiaq.org/conference_proceedings.php).

[9] Health Canada. 2010. *Reducing radon levels in existing homes: a Canadian guide for professional contractors*. Accessed November 1st, 2022: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/radiation/reducing-radon-levels-existing-homes-canadian-guide-professional-contractors-health-canada-2010.html.

[10] UNSCEAR. *Sources, effects and risks of ionizing radiation*. Report to the general assembly and scientific annexes A and B. UNSCEAR 2019. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations sales publication E.20.IX.5. United Nations, New York, 2021. https://www.unscear.org/unscear/en/publications/2019.html.

[11] Richardson D.B., *et al.*, 2022. *Lung cancer and radon: pooled analysis of uranium miners hired in 1960 or later*. Environmental Health Perspectives. 130:5 CID: 057010. DOI: https://doi.org/10.1289/EHP10669.

[12] Chen, J., *et al.*, 2010. *Radon exhalation from building materials for decorative use*. Journal of Environmental Radioactivity. 101(4):317-322. DOI: https://doi.org/10.1016/j.jenvrad.2010.01.005.

[13] Bergman, L., *et al.*, 2015. *Radon exhalation from sub-slab aggregate used in home construction in Canada* Radiation Protection Dosimetry. 164(4):606-611. DOI: https://doi.org/10.1093/rpd/ncv320.

Other useful resources

Dowdall, A., *et al*., 2017, *Update of Ireland's national average indoor radon concentration – Application of a new survey protocol*. J Environ Radioact. 169-170:1-8 DOI: https://doi.org/10.1016/j.jenvrad.2016.11.034.

Hodgson, S.A., *et al*., 2019, *Radon: analysis of Remediation Methods*. HPA-CRCE-019. Available from: https://www.gov.uk/government/publications/radon-analysis-of-remediation-methods.

UK's Building Research Establishment (BRE), *BR 211-Radon-Guidance on protective measures for new buildings (2015 Edition) guidance document*, in Figure 26, Page 18: https://www.bre.co.uk/page.jsp?id=3139.

ANSI/AARST, 2018. *Soil Gas Systems in New Construction of Buildings.* Available from here: https://webstore.ansi.org/standards/aarst/ansiaarstcc10002018.