Submit a comment

Proposed Change 1713

Code Reference(s):	**NBC20 Div.B 9.13.4. (first printing)**
Subject:	Radon and Soil Gas Mitigation
Title:	Passive Vertical Radon Stack
Description:	This proposed change adds requirements for radon mitigation by use of a passive vertical radon stack in dwelling units and home-type care occupancies that have a wall, roof or floor assembly in contact with the ground.
Related Code Change Request(s):	CCR 895, CCR 951, CCR 1330

This change could potentially affect the following topic areas:

- [ ] Division A
- [ ] Division C
- [ ] Building operations
- [x] Small Buildings
- [ ] Fire Protection
- [ ] Accessibility
- [ ] Building Envelope
- [ ] Heating, Ventilating and Air Conditioning
- [x] Division B
- [ ] Design and Construction
- [x] Housing
- [ ] Large Buildings
- [x] Occupant safety in use
- [ ] Structural Requirements
- [ ] Energy Efficiency
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

Radon is a colourless, odourless, radioactive gas that occurs naturally as a result of the decay of radium. It is found in varying concentrations as a component of soil gas in all regions of Canada. It is known to enter dwelling units by infiltration into basements and crawl spaces.

Health Canada estimates that 7% of homes in Canada have levels exceeding the Canadian Guideline of 200 becquerels per metre cubed (Bq/m^3) [1]. However, research has shown that the majority of cases of radon-induced lung cancer occur in residents of dwellings that have concentrations of radon lower than 200 Bq/m^3. Radon is the second-leading cause of lung cancer deaths in Canada, after smoking. It accounts for 16% of lung cancer deaths, which is 3,200 Canadian deaths annually.

The potential for high levels of radon infiltration is very difficult to evaluate prior to construction, and thus a radon problem may only become apparent once the building is completed and occupied. The Canadian Guideline also recommends that construction of new buildings use techniques that minimize radon entry into conditioned space [1].

Current NBC provisions mandate the installation of an air barrier system between wall, roof and floor assemblies separating conditioned space from the ground and the provision of a rough-in for a radon extraction system. Although these provisions may facilitate the implementation of mitigation measures following proper testing of post-construction radon ingress, research has shown that these provisions do not mitigate radon ingress into conditioned spaces and, therefore, do not reduce exposure to radon.

Justification

This proposed change introduces a requirement for the installation of a passive stack subfloor depressurization system during initial construction. A passive stack subfloor depressurization system has been shown to reduce the level of radon by 40% to 90%, thus limiting the probability of negative effects on indoor air quality, including cases of radon-induced lung cancer.

There is no safe level of radon. The higher the radon concentration, the higher the risk of lung cancer. Therefore, an approach that minimizes radon entry during the construction of all buildings presents a much greater benefit because radon exposure in general is reduced, in contrast to the approach of post-occupancy testing with mitigation for only the highest levels of radon exposure. For example, it was estimated that most lung cancer deaths attributable to radon in Ontario (89%) would occur for levels of radon exposure below 200 Bq/m^3 and could not be prevented by post-occupancy testing and mitigation [2].

The proposed system (passive stack subfloor depressurization system installed during initial construction) is considered the ideal solution since the modification of an existing capped rough-in, installed according to the NBC, requires the installation of an active fan or alterations to existing walls and floor, which could cost two to three times more than the installation of the proposed system. This proposed change only addresses Part 9 dwelling units and home-type care occupancies, given that people only occupy other types of Part 9 occupancies about 25% of the time.

References

[1] Health Canada. Radon: A Guide for Canadian Homeowners. Canada Mortgage and Housing Corporation. NH15-180/1997E. 2007.

[2] Emily Peterson, Amira Aker, JinHee Kim, Ye Li, Kevin Brand and Ray Copes. "Lung cancer risk from radon in Ontario, Canada: how many lung cancers can we prevent?" Cancer Causes Control. 2013; 24(11): 2013–2020.

PROPOSED CHANGE

[9.13.4.] 9.13.4. Soil Gas Control

(See Note A-9.13.4.)

[9.13.4.1.] 9.13.4.1. Application and Scope

[1] 1) This Subsection applies to

[a] a) ~~wall, roof and floor assemblies separating~~a *conditioned space* ~~from the ground, and~~that has a wall, roof or floor assembly that is in contact with the ground,

[b] b) the rough-in ~~to allow the future protection~~ of a *conditioned space* that has~~is separated from the ground by~~ a wall, roof or floor assembly~~.~~ that is in contact with the ground, and

[c] --) a passive vertical radon stack for a *conditioned space* that has a wall, roof or floor assembly that is in contact with the ground.

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

[9.13.4.2.] 9.13.4.2. Protection from Soil Gas Ingress

[1] 1) All wall, roof and floor assemblies separating a *conditioned space* from the ground shall be ~~protected by~~provided with an *air barrier system* conforming to Subsection 9.25.3. that provides a level of radon diffusion protection equivalent to that provided by 0.15 mm polyethylene sheet conforming to CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet for Use in Building Construction."

[2] 2) ~~Unless the space between the *air barrier system* and the ground is designed to be accessible for the future installation of a subfloor depressurization system,~~ *D~~d~~welling units* and *home-type care occupancies* where 10% or more of the total area of a wall, roof or floor assembly separates a *conditioned space* from the ground~~and *buildings* containing *residential occupancies*~~ shall be provided with ~~the rough-in for a radon extraction system~~ a passive vertical radon stack conforming to Article 9.13.4.4. and made of components that are compatible with adjoining materials described in Articles 9.13.4.3. and 9.13.4.4.

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

[a] a) Article 9.13.4.3., or

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

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

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

~~(See Note A-9.13.4.3.)~~

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

[a] a) a gas-permeable layer, an inlet and an outlet as described in Sentence (2), or

[b] b) clean granular material and a pipe as described in Sentence (3).

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

[a] a) a gas-permeable layer installed in the space between the air barrier and the ground to allow the depressurization of that space,

[b] b) an inlet that allows for the effective depressurization of the gas-permeable layer (see Note A-9.13.4.3.(2)(b) and (3)(b)(i)), and

[c] c) an outlet in the *conditioned space* that

[i] i) permits connection to depressurization equipment,

[ii] ii) is sealed to maintain the integrity of the *air barrier system*, and

[iii] iii) is clearly labeled to indicate that it is intended only for the removal of radon from below the floor-on-ground.

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

[a] a) clean granular material installed below the floor-on-ground in accordance with Sentence 9.16.2.1.(1), and

[b] b) a pipe not less than 100 mm in diameter installed through the floor, such that

[i] i) its bottom ~~end~~ opening~~s~~ is located in~~to~~ the granular layer required in Clause (a) at or near the centre of the floor and not less than 100 mm of granular material projects beyond the bottom opening~~terminus~~ of the pipe measured along its axis (see Note A-9.13.4.3.(2)(b) and (3)(b)(i)),

[ii] --) its bottom opening is protected by a low-pressure-drop stainless steel mesh with 10 mm to 12.5 mm openings or by a product and fitting system that provide an equivalent level of air-flow performance and corrosion resistance,

[iii] ii) its top opening~~end~~ permits connection to depressurization equipment and is provided with an airtight cap, unless a passive vertical radon stack conforming to Article 9.13.4.4. is connected to the rough-in, and

[iv] iii) the pipe is clearly labeled near the cap and, if applicable, at every 1.8 m and at every change in direction to indicate that it is intended only for the removal of radon from below the floor-on-ground.

[9.13.4.4.] --- Passive Vertical Radon Stack

[1] --) The passive vertical radon stack required by Sentence 9.13.4.2.(2) shall be installed

[a] --) in a *conditioned space* in accordance with Clauses 7.2.2.3 and 7.2.3.2 to 7.2.4.3 of CAN/CGSB-149.11-2019, "Radon control options for new construction in low-rise residential buildings,"

[b] --) except as provided in Sentence (2), in the vertical direction, and

[c] --) such that its rooftop termination conforms to Table 9.13.4.4.-A.

Table [9.13.4.4.-A]
Minimum Clearances for Rooftop Termination of Passive Vertical Radon Stacks
Forming Part of Clause 9.13.4.4.(1)(c)

Description	Minimum Clearance, m
Vertical clearance above the roof at the point of penetration	0.15
Vertical clearance above windows and doors	0.6
Vertical clearance above mechanical air intakes	0.9
Horizontal clearance from windows, doors and mechanical air intakes	3
Clearance horizontally from vertical walls that extend above the penetrated roof	3

[2] --) Where it is not possible to install a passive vertical radon stack entirely in the vertical direction, the stack is permitted to include a horizontal offset on each *storey*, including the *basement*, provided each offset

[a] --) is not more than 3.6 m long,

[b] --) is connected using 22.5° to 90° fittings, and

[c] --) has a slope not less than 1 in 50.

(See Note A-9.13.4.4.(2).)

[3] --) Piping and connections for the passive vertical radon stack

[a] --) shall conform to Clauses 7.1.3.1.1 to 7.1.3.1.3 and 7.1.3.1.5 to 7.1.3.2.6 of CAN/CGSB-149.11-19, "Radon control options for new construction in low-rise residential buildings," and

[b] --) shall not be perforated above the level of the air barrier system.

[4] --) Piping runs for the passive vertical radon stack that are located inside hollow walls or partitions within 43 mm of the wall or partition surface shall be protected against physical damage and puncture at the intersections of joists, studs, plates and other framing members by the use of steel plates or sleeves not less than 1.59 mm thick.

[5] --) Except as provided in Sentence (6), the portion of the passive vertical radon stack that passes through the unconditioned *attic or roof space* shall be

[a] --) located within a cylindrical space not less than 500 mm in diameter and not less than 1 000 mm high, and

[b] --) insulated in accordance with Table 9.13.4.4.-B.

(See Note A-9.13.4.4.(5) and (6).)

Table [9.13.4.4.-B]
Insulation of Passive Vertical Radon Stack in Unconditioned Space
Forming Part of Clause 9.13.4.4.(5)(b)

2.5% January Design Temperature, °C	Maximum Stack Height Above Roof, m	Insulation, RSI					
		0.70	1.41	2.11	2.82	3.52	4.23
		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
−6 to −11	0.30	2.59	3.91	4.83	5.53	6.29	6.86
−12 to −17	0.30	1.28	2.59	3.08	3.43	3.78	4.11
−18 to −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 (1)	1.51	2.32	2.93	3.47	3.90	4.30
−25 to −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 (1)	1.34	1.92	2.47	2.90	3.26	3.60
−30 to −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 (1)	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 (1)	1.22	1.65	2.07	2.44	2.77	3.05
	0.30 (1)	1.05	1.28	1.74	2.01	2.29	2.53

Note to Table [9.13.4.4.-B] :

(1) The portion of the passive vertical radon stack that extends above the roof shall be insulated to RSI 0.704 and protected from physical damage.

[6] --) Where it is not possible to provide the cylindrical space described in Clause (5)(a) within an unconditioned *attic or roof space* or where the passive vertical radon stack passes through a *dwelling unit* above, the

cylindrical space shall be provided within the *conditioned space*. (See Note A-9.13.4.4.(5) and (6).)

[7] --) The top opening of the passive vertical radon stack shall be fitted with a stainless steel mesh with 10 mm to 12.5 mm openings or by a product and fitting system that provide an equivalent level of air-flow performance and corrosion resistance.

Note A-9.13.4. Soil Gas Control.

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

Sentence 9.13.4.2.(1), which requires the installation of an air barrier system, addresses the protection from all common naturally occurring soil gases, including nitrogen, carbon dioxide, oxygen, methane and radon, while the remainder of Article 9.13.4.2. along with Articles 9.13.4.3. and 9.13.4.4., which require the provision of the means to depressurize the space between the air barrier and the ground, specifically address the capability to mitigate high radon concentrations in the future, should this become necessary.

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

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

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

The principal method of resisting the ingress of all soil gases, a resistance which is required for all buildings (see Sentence 9.13.4.2.(1)), is to seal the interface between the soil and the occupied space, so far as is reasonably practicable. Sections 9.18. and 9.25. contain requirements for air and soil gas barriers in assemblies in contact with ground, including those in crawl spaces. Providing control joints to reduce cracking of foundation walls and airtight covers for sump pits (see Section 9.14.) are other measures that can help achieve this objective. The requirements provided in Subsection 9.25.3. are explained in Notes A-9.25.3.4. and 9.25.3.6. and Note A-9.25.3.6.(2) and (3).

The principal method of ~~excluding radon~~minimizing radon infiltration into a building is to ensure that the pressure difference across the ground/space interface is positive (i.e., towards the outside) so that the inward flow of radon through any remaining leaks will be minimized. The requirements provided in Article 9.13.4.3. are explained in Note A-9.13.4.3.

Note A-9.13.4.3.

~~**Completion of a Subfloor Depressurization System**~~

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

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

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

Note A-9.13.4.4.(2) Fitting Angles for Horizontal Offsets.

The use of a straight pipe as a passive vertical radon stack is preferable to facilitate soil gas flow, but is not always possible in practice. Where horizontal offsets are required, the use of fittings with shallow angles is preferable to minimize the restriction of soil gas flow. However, fittings with angles up to 90° are acceptable for use in restricted spaces where a horizontal assembly using fittings with shallow angles is not feasible.

Note A-9.13.4.4.(5) and (6) Open Space Around the Passive Vertical Radon Stack.

Sentences 9.13.4.4.(5) and (6) require the provision of an open cylindrical space around the passive vertical radon stack to allow for the potential future installation of an active radon mitigation fan. If necessary, such a fan may be installed to reduce high radon concentrations that become apparent once the building is completed and occupied.

Impact analysis

Refer to the Impact Analysis Document, "Impact Analysis of Installing Passive Radon Stacks in Part 9 Residential Occupancies," for the full impact analysis. An Executive Summary is reproduced here.

The benefits of reducing radon by installing passive vertical radon stacks followed a pattern typical of preventive interventions, with the direct costs incurred up front and a delay before the benefits are experienced. The direct benefits included the number of lung cancer deaths that would be prevented and the associated lung cancer treatment costs avoided following the reduction in residential radon exposures. The results of the analysis were presented in two parts:

1. Example case: passive vertical radon stacks installed in relevant Part 9 units built in 1 year
2. Full analysis: passive vertical radon stacks installed in relevant Part 9 units built over 100 years

The methodology used to estimate the benefits of installing passive vertical radon stacks was defined as follows:

- two estimates of current radon exposure (lower and upper)
- effectiveness of passive vertical radon stacks at reducing indoor radon based on recent field studies
- 75-year service life of passive vertical radon stacks
- excess relative risk of lung cancer from radon modelled using cumulative radon exposure resulting from the duration and concentration of radon exposure over time (BEIR VI model)
- lung cancer incidence and survival defined by type and stage at diagnosis
- lifetable approach based on lung cancer incidence, all-cause mortality, and smoking prevalence

In 2021, the annual cost of installing passive vertical radon stacks in the 117,742 units of Part 9 residential occupancies in contact with the ground built in that one-year period was estimated to be $112,897,401 ($93,633,327–$131,261,476). The annual lung cancer cases prevented—and, therefore, the annual lung cancer treatment costs prevented—increased over the 75-year service life of the passive vertical radon stacks because there was a greater reduction in the relative annual risk of lung cancer for residents who lived for a longer period with reduced radon exposure.

The total lung cancer treatment costs prevented over the 75-year lifespan of the 117,742 units of new housing built in 2021 with passive vertical radon stacks installed ranged from $10 million to $16 million, at $10,231,105 ($8,443,980–$12,047,540) and $16,050,125 ($14,278,700–$17,554,105) for the lower and upper radon estimates, respectively. A total of 141 (117–167) and 222 (197–242) lung cancer deaths were estimated to be prevented for the lower and upper radon estimates, respectively, in the residents of the 117,742 units over 75 years following the installation of passive vertical radon stacks.

The impact analysis for this proposed change on installing passive vertical radon stacks in Part 9 residential occupancies demonstrated that the main benefit would be preventing 10,000 to 16,000 radon-associated lung cancer deaths in Canada over 100 years should this proposed change be adopted. The cumulative number of lung cancer deaths prevented over 100 years was estimated to be 10,356 (8,601–12,208) for the lower residential radon exposure and 16,132 (14,402–17,586) for the upper estimate of current residential radon exposure. Although the costs incurred for installing passive vertical radon stacks in new housing construction always exceeded the savings from lung cancer treatment for cases prevented, the cumulative cost per lung cancer death prevented decreased steeply after implementation and dropped below the Treasury Board of Canada Secretariat reference value after 30 to 40 years.

Enforcement implications

The proposed change would require the inspection of the passive subfloor depressurization system from where the capped rough-in previously ended to where it would terminate with the proposed change (i.e., above the roof line).

Who is affected

Designers may need to change their designs to better facilitate the termination of the passive vertical radon stack above the roof. This proposed change may require moving walls or changing framing to thicken walls to conceal the passive vertical radon stack or moving the location where the sub-slab collection pipe penetrates the slab.

Contractors would be required to add the passive subfloor depressurization system to their construction procedures. This proposed change may require them to change their designs to better facilitate the termination of the passive vertical radon stack above the roof. This change may also require moving walls or changing framing to thicken walls to conceal the passive vertical radon stack or moving the location where the sub-slab collection pipe penetrates the slab.

Occupants would benefit from the reduction of exposure to radon gas. This proposed change may require them to change their designs to better facilitate the termination of the passive vertical radon stack above the roof. This change may also require moving walls or changing framing to thicken walls to conceal the passive vertical radon stack or moving the location where the sub-slab collection pipe penetrates the slab.

Supporting Document(s)

Impact Analysis of Installing Passive Radon Stacks in Part 9 Residential Occupancies (pcf_1713_impact_analysis_edited_mjv_am_clean.pdf)

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[9.13.4.1.] 9.13.4.1. ([1] 1) no attributions

[9.13.4.1.] 9.13.4.1. ([2] 2) no attributions

[9.13.4.2.] 9.13.4.2. ([1] 1) no attributions

[9.13.4.2.] 9.13.4.2. ([1] 1) [F40-OH1.1]

[9.13.4.2.] 9.13.4.2. ([2] 2) [F40-OH1.1]

[9.13.4.2.] 9.13.4.2. ([3] 3) [F40-OH1.1]

[9.13.4.3.] 9.13.4.3. ([1] 1) [F40-OH1.1]

[9.13.4.3.] 9.13.4.3. ([2] 2) [F40-OH1.1]

[9.13.4.3.] 9.13.4.3. ([3] 3) [F40-OH1.1]

[9.13.4.4.] -- ([1] --) [F40-OH1.1]

[9.13.4.4.] -- ([2] --) [F40-OH1.1]

[9.13.4.4.] -- ([4] --) [F40-OH1.1]

[9.13.4.4.] -- ([4] --) [F40-OH1.1]

[9.13.4.4.] -- ([5] --) [F40-OH1.1]

[9.13.4.4.] -- ([5] --) [F51-OH1.1]

[9.13.4.4.] -- ([6] --) [F40-OH1.1]

[9.13.4.4.] -- ([7] --) [F42-OH2.5]