

NBC 2020 – Soil gas control (floors-on-ground) CCMC evaluations

**A GOVERNMENT OF CANADA SERVICE FOR
CANADIAN CONSTRUCTION AUTHORITIES**

BOABC Conference • May 29, 2024
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OVERVIEW

1. Radon and pathways through the building
2. NBC, Part 9 requirements for soil gas control
3. CCMC evaluations
 - Soil gas barrier
 - Gas permeable layer

Radon – Basic concept

Radon

- Natural radioactive material
- Breakdown of uranium/radium
- Found in soil, rock and water
- Can not be seen, smelled or tasted

Health issues

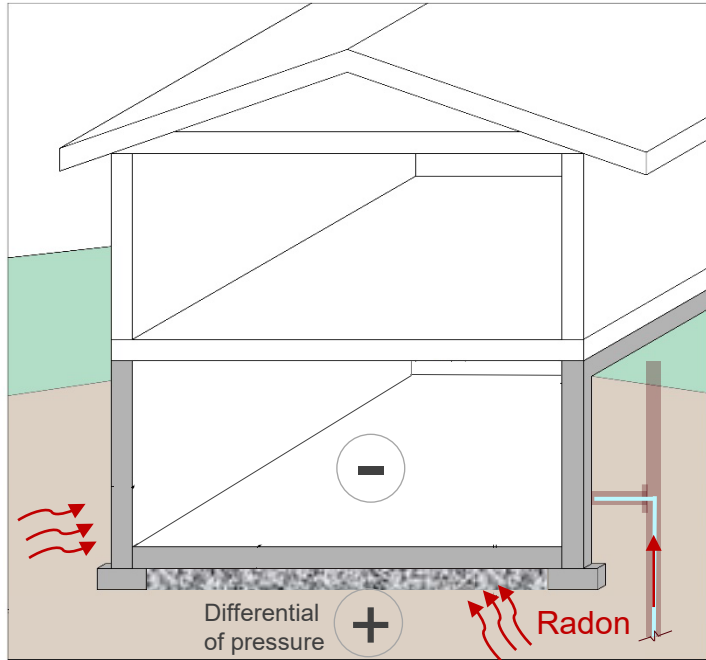
- Radioactive particles can get lodged into lung tissue
- Release energy that can damage lung cells
- Potential cause of cancer



Radon concentration in air is measured in:
becquerels per cubic meter
(Bq/m³)

Gov. of Canada guidelines
for radon protection

Potential sources of radon



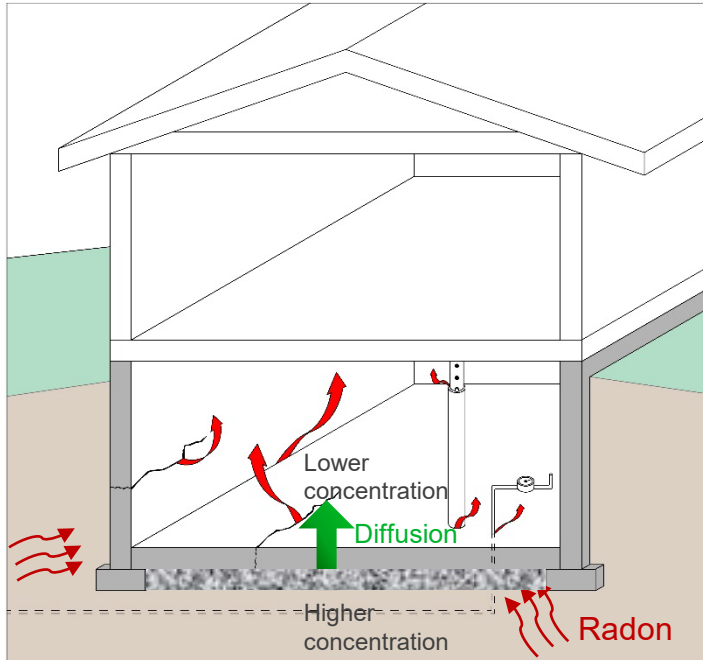
Water wells

Soil in contact with buildings

Construction materials

NBC, Part 9 – addresses only radon in the air that originates from the soil

Radon pathways to the building



Cracks

In foundation wall and floor slab

Joints

Floor/wall perimeter

Gaps

At penetrations (pipes, steel columns)

Other services

Sum pits covers, floor drains

Exposed soil in crawl space

NBC 2020 requirements – Part 9

9.13.4., Soil Gas Control

9.13.4.1. Application and Scope

9.13.4.2. Protection from Soil Gas Ingress

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

Soil gas: mixture of air, water vapour and pollutants



Same requirements in
NBC 2015 and 2020

Article 9.13.4.1. – Application and Scope

- 1) This Subsection applies to
 - a) wall, roof and floor assemblies separating conditioned space from the ground, and
 - b) the rough-in to allow the future protection of conditioned space that is separated from the ground by a wall, roof or floor assembly.
- 2) This Subsection addresses the leakage of soil gas from the ground into the building.



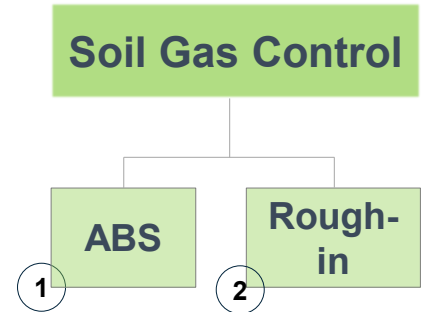
Article 9.13.4.2. – Protection from Soil Gas Ingress

- 1) All wall, roof and floor assemblies separating *conditioned space* from the ground shall be protected by an air barrier system conforming to **Subsection 9.25.3.** 1
- 2) Unless the space between the *air barrier system* and the ground is designed to be accessible for the future installation of a subfloor depressurization system, *dwelling units* and *buildings* containing *residential occupancies* shall be provided with the rough-in for a radon extraction system conforming to **Article 9.13.4.3.** 2
- 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
 - 1) Article 9.13.4.3., or
 - 2) Parts 5 and 6 (see Article 5.4.1.1. and 6.2.1.1.).(See Note A-9.13.4.2.(3).)



ABS

Rough-in



Subsection 9.25.3. – Air Barrier Systems

9.25.3.1. Required Barrier to Air Leakage

9.25.3.2. Air Barrier System Properties

9.25.3.3. Continuity of the Air Barrier System

9.25.3.4. Air Leakage Control in Masonry Walls

9.25.3.5. Air leakage Control in Underground Roofs

9.25.3.6. Air barrier System in Floors-on-grounds

**Objectives and requirements
for all ABS**

Beyond scope of the presentation

Focus on soil gas control

Article 9.25.3.6. – Air Barrier Systems in Floors-on-ground

1) Materials used to provide a barrier to the ingress of air through floors-on-ground shall conform to CAN/CGSB-51.34-M, “Vapour Barrier, Polyethylene Sheet for Use in Building Construction.”

6 mils poly

2) Where the floor-on-ground is a concrete slab, the air barrier shall be
a) installed below the slab, or
b) applied to the top of the slab, provided a separate floor is installed over the slab.
(See Note A-9.25.3.6.(2) and (3).)

Location above or below slab

3) Where the air barrier installed below a floor-on-grounds is flexible sheet material, joints in the barrier shall be lapped not less than 300 mm. (See Note A-9.25.3.6.(2) and (3).)

**Below slab
Lapped joints 300 mm**

4) Where installed in conjunction with a framed floor-on-ground or above a floor-on-ground, the air barrier shall be installed in accordance with Article 9.25.3.3.

**Above slab
Continuity**

5) A floor-on-ground shall be sealed around its perimeter to the inner surfaces of adjacent walls using flexible sealant.

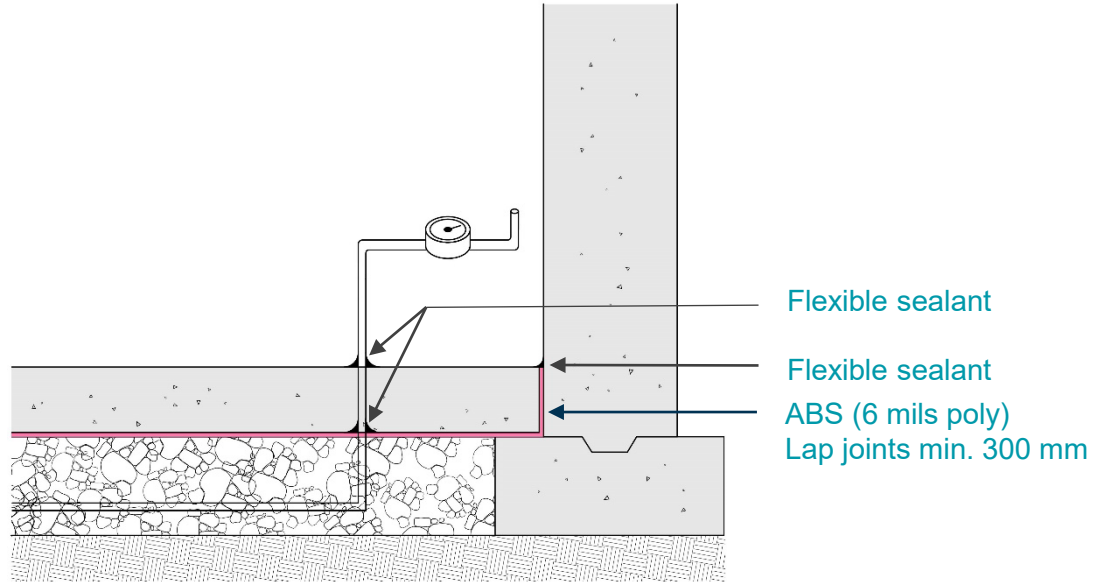
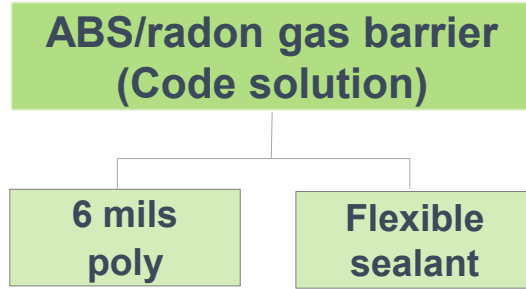
Sealed to walls

6) All penetrations of a floor-on-ground that are required to drain water from the floor surface shall be sealed in a manner that prevents the upward flow of air without preventing the downward flow of liquid water.

**Drain protection
against upward flow**



Article 9.25.3.6. – Air Barrier Systems in Floors-on-ground

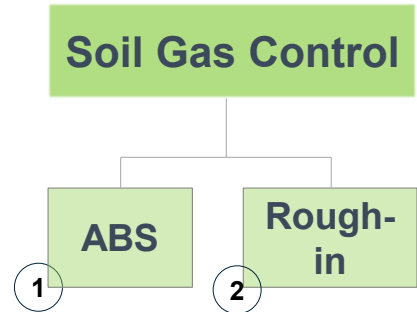


Article 9.13.4.2. – Protection from Soil Gas Ingress

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 - 2) Parts 5 and 6 (see Article 5.4.1.1. and 6.2.1.1.).(See Note A-9.13.4.2.(3).)



Rough-in



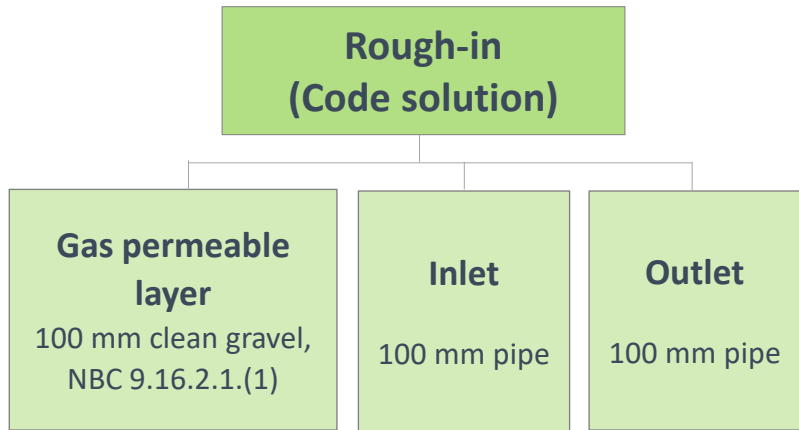
Article 9.13.4.3. – Providing the Rough-in for a Subfloor Depressurization System

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

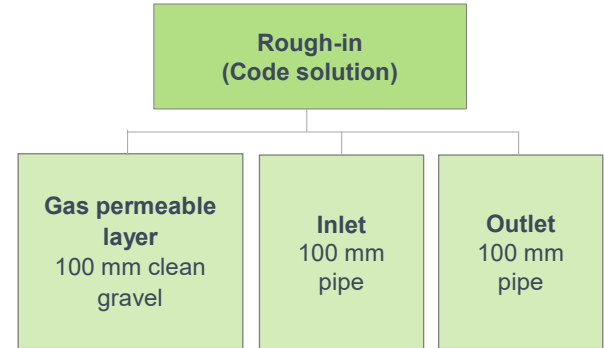
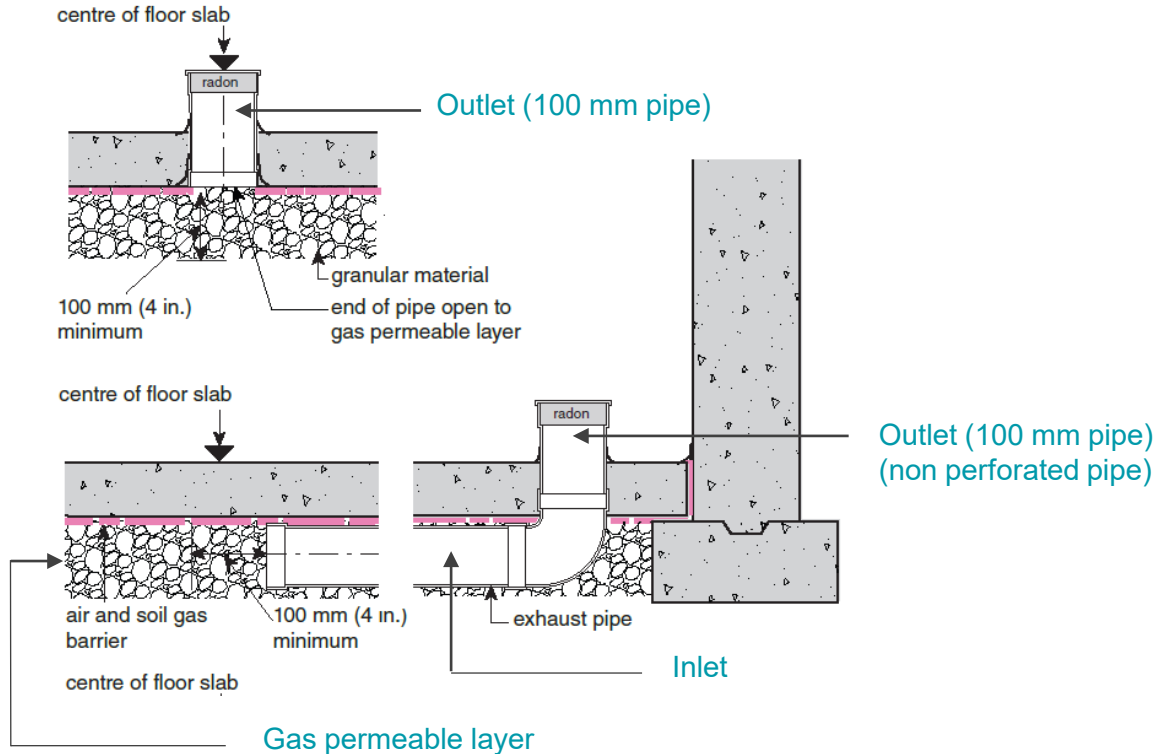
- (a) – gas permeable layer + inlet + outlet, or
- (b) – clean granular material + pipe

9.13.4.3.(2) – Performance-based solution →

9.13.4.3.(3) – Prescriptive solution →



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



Complete depressurization system – beyond Code

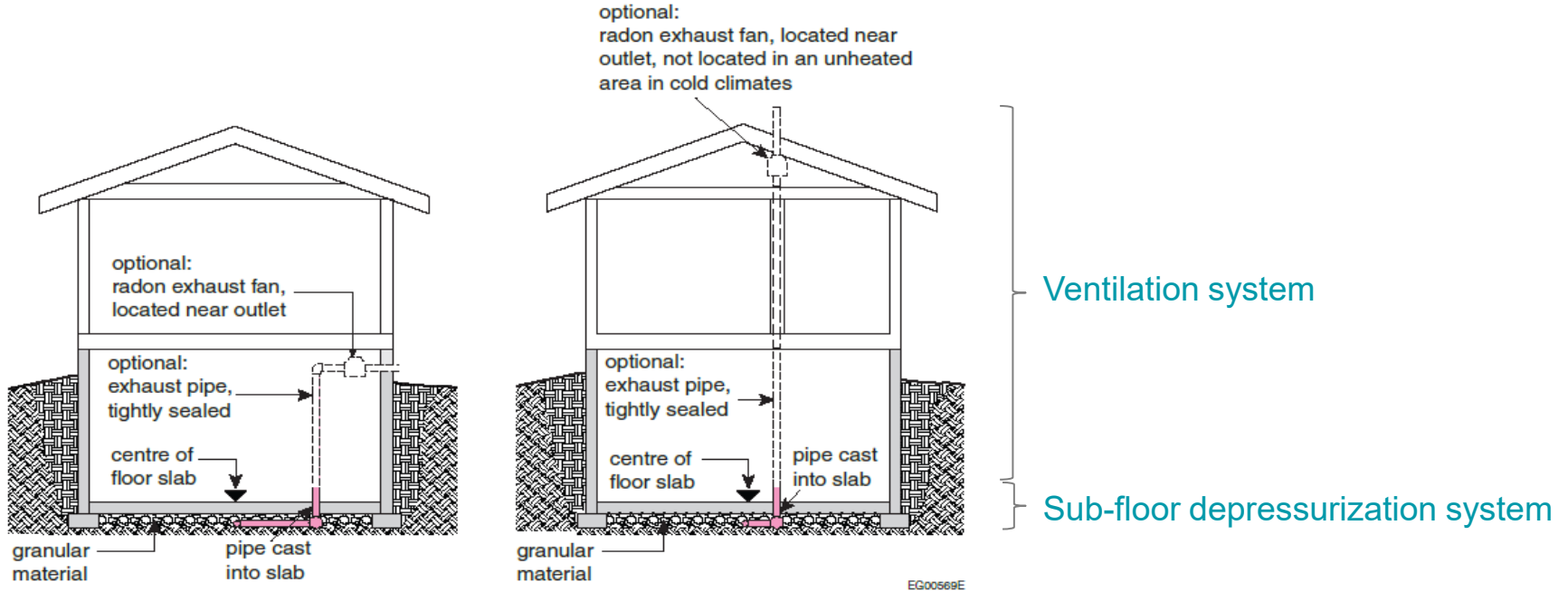


Figure 9.13.-8, Illustrated User's Guide
NBC 2015, Part 9 of Division B

Article 9.13.4.3. – Rough-in

(See Note A-9.13.4.3.)

- 1) Floors-on-ground shall be provided with a rough-in for subfloor depressurization consisting of
 - a) a gas-permeable layer, an inlet and an outlet as described in Sentence (2), or
 - b) clean granular material and a pipe as described in Sentence (3).
- 2) The rough-in referred to in Clause (1)(a) shall include
 - a) a gas permeable layer installed in the space between the air barrier and the ground to allow the depressurization of that space,
 - b) an inlet that allows for the effective depressurization of the gas-permeable layer (see Note A-9.13.4.3.(2)(b) and (3)(b)(i), and
 - c) and outlet in the conditioned space that
 - i. permits connection to depressurization equipment,
 - ii. is sealed to maintain the integrity of the air barrier system, and
 - iii. is clearly labeled to indicate that it is intended only for the removal of radon from below the floor-on-ground.



Choice between performance-based or prescriptive solution

Performance-based solution

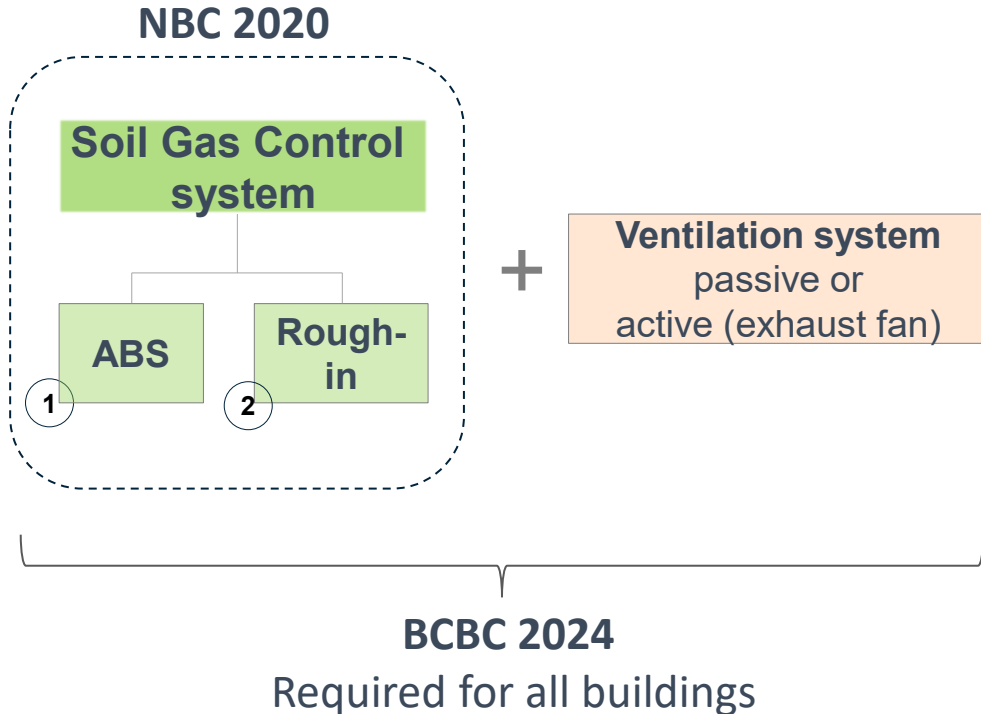
Article 9.13.4.3. – Rough-in

- 3) The rough-in referred to in Clause (1)(b) shall include
- a) clean granular material installed below the floor-on-ground in accordance with Sentence 9.16.2.1.(1), and
 - b) a pipe not less than 100 mm in diameter installed through the floor, such that
 - i. its bottom end opens into the granular layer required in Clause (a) at or near the centre of the floor and not less than 100 mm of granular material projects beyond the terminus of the pipe measured along its axis (see Note A-9.13.4.3.2.(2)(b) and (3)(b)(i)),
 - ii. its top end permits connection to depressurization equipment and is provided with an airtight cap, and
 - iii. the pipe is clearly labeled near the cap and, if applicable, every 1.8 m and at every change in direction to indicate that it is intended only for removal of radon from below the floor-on-ground.

**Prescriptive
solution**

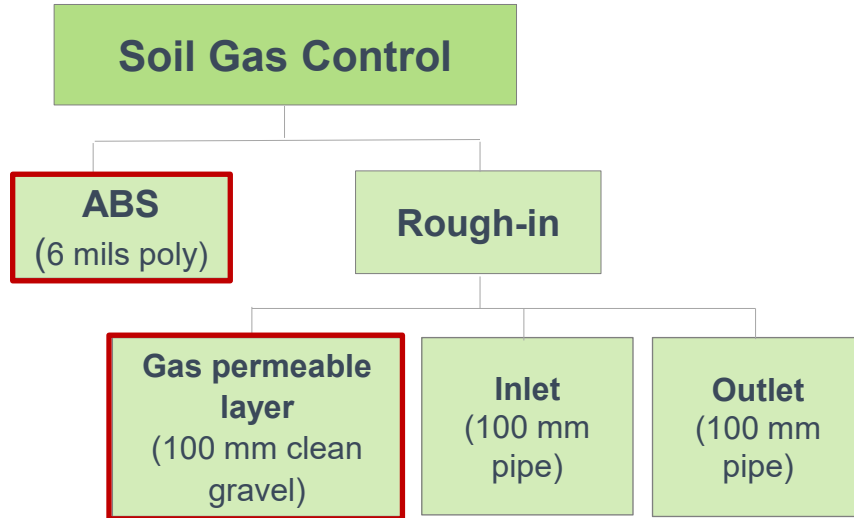


Complete depressurization system – beyond NBC



CCMC evaluations – alternative solutions

Soil gas control below concrete slab application



Spray foam



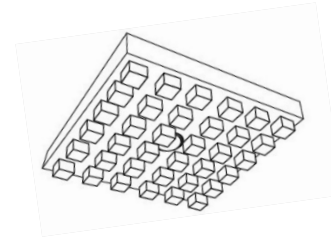
XPS panels



PE sheet

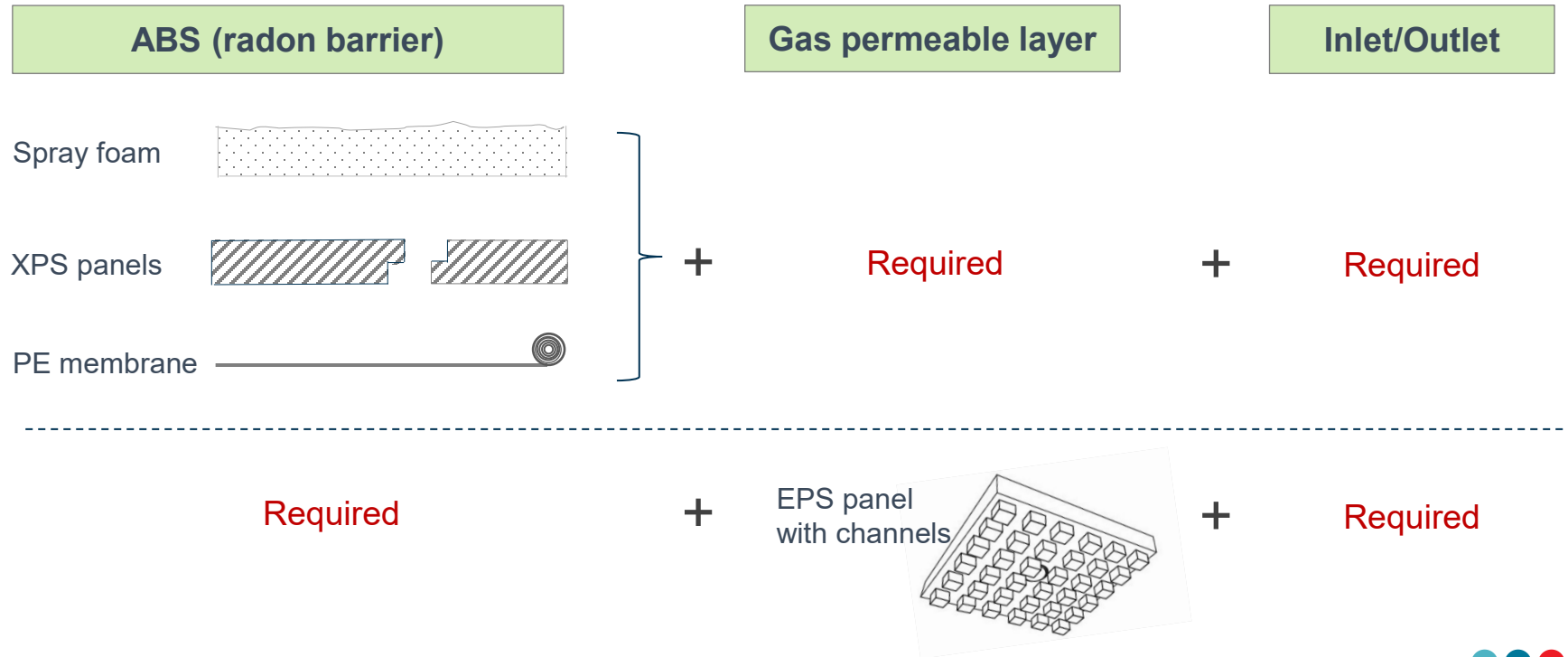


EPS panel
with channels



CCMC evaluations – alternative solutions

Soil gas control below concrete slab application



Evaluated ABS (radon barrier)

Product description

- Spray foam, XPS panels and PE membrane

Function

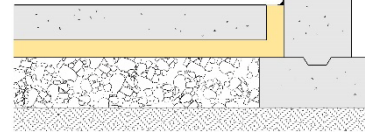
- ABS/radon gas barrier

Conditions and limitations – Part 9

- Be continuous (may need accessories such as transition membrane, tape, flexible sealant, air foam sealant, etc.)
- Over 100 mm gravel layer (with adjusted thickness due to foam penetration)
- Rough-in
- Dry service conditions

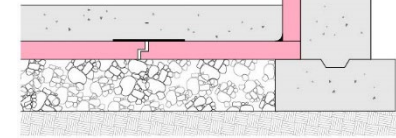
Spray foam insulation

CCMC 14152-R
CCMC 14280-R
CCMC 14445-R



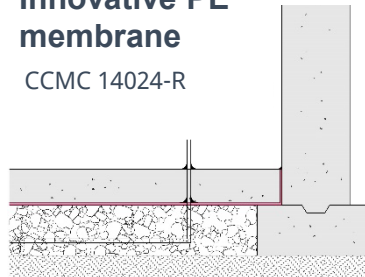
Polystyrene (XPS) panel insulation

CCMC 14349-R



Innovative PE membrane

CCMC 14024-R



Evaluated ABS (radon barrier)

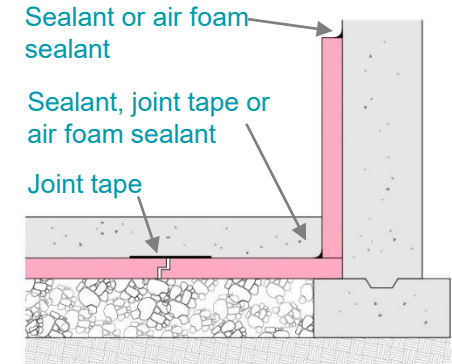
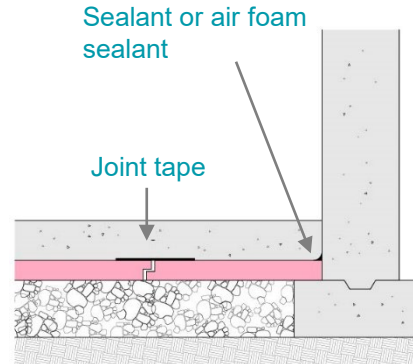
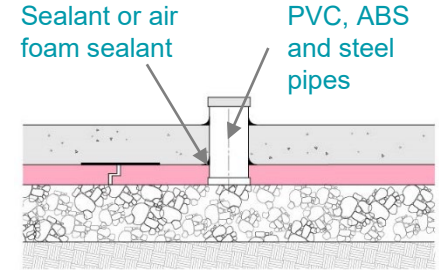
Example: XPS panel insulation system
CCMC 14349-R

Description

Extruded polystyrene foam panels (XPS Type 3), 25 and 50 mm thick (1 and 2 in.)

Floor system accessories

Accessories: air foam sealant, flexible sealant and joint tape



CCMC Technical Guide for ABS (radon gas barrier)

Testing protocol

1. Materials qualification (basic properties, XPS durability and radon diffusion)
2. Airtightness/radon infiltration – system performance
3. Mechanical damage resistance and penetration in gravel
4. Optional - Dampproofing characteristics

Alternative solution

XPS foam insulation with accessories



NBC solution

6 mils poly with min 300 mm lapped joints and flexible sealant

Evaluation – XPS foam panels system

1. Materials qualification



XPS panel

Basic properties
CAN/ULC-S701

XPS foam durability
ULC-S742/CCMC requirements

XPS Radon diffusion and radon resistance

NRC – RDTC test



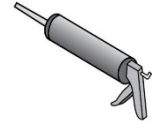
Bead-applied one-component polyurethane expanding foam

Basic properties
CAN/ULC-S710



Joint tape

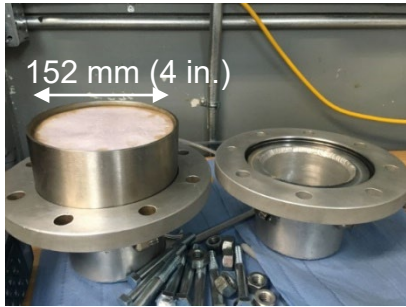
Basic properties
CCMC requirements



Flexible sealant

Basic properties
Meet NBC referenced standards

Evaluation – XPS foam panels system



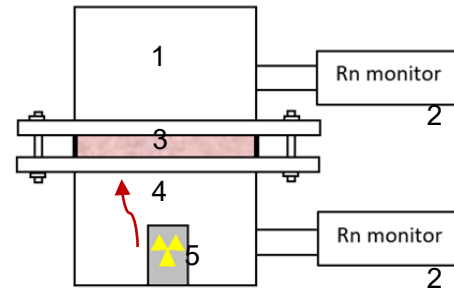
RDTC

RDTC – NRC Apparatus

Radon Diffusion Test Chamber for testing material permeance to radon gas diffusion



Glove box



Schematic of RDTC

Property	Performance
Radon resistance prior and after mechanical damage	XPS panels \geq Code 6 mils poly

1. Receiving compartment

- XPS: Rn concentration very low
- 6 mils poly: Rn concentration 200 000 Bq/m³

2. Rn (radon) monitor

3. Test sample

4. Dosing compartment

- XPS: Rn concentration 1.5 Million Bq/m³
- 6 mils poly: Rn concentration 1.5 Million Bq/m³

5. Radon source

Evaluation – XPS foam panels system

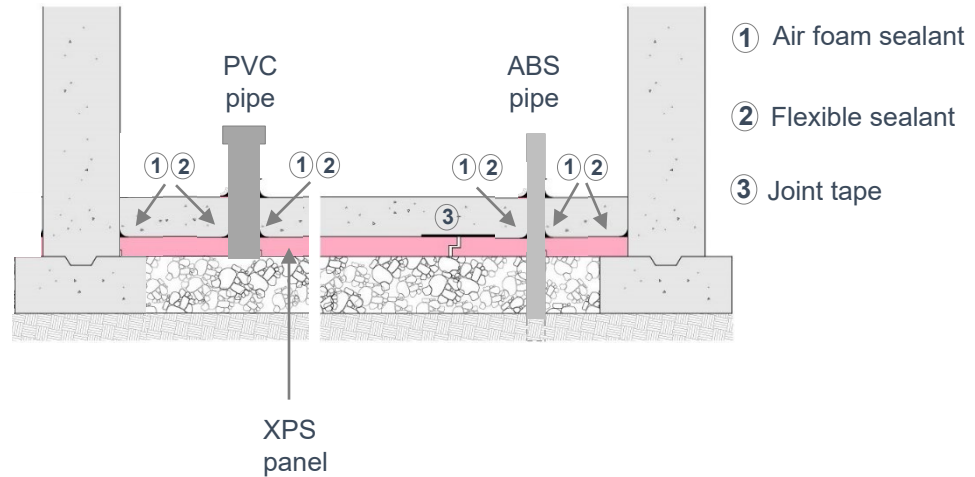
2. Airtightness/radon infiltration – system performance

Air tightness (with pipes)
ASTM E2178 at 75 Δ Pa
(6 air leakage rates: 25 to 300 Pa)

Additional airtightness verification
NRC DWTF (ASTM E2357) and
modified ULC-S710

Radon infiltration
(wall junction + PVC pipe)

NRC – RIBETS test



Radon infiltration (NRC facilities)



Exterior view

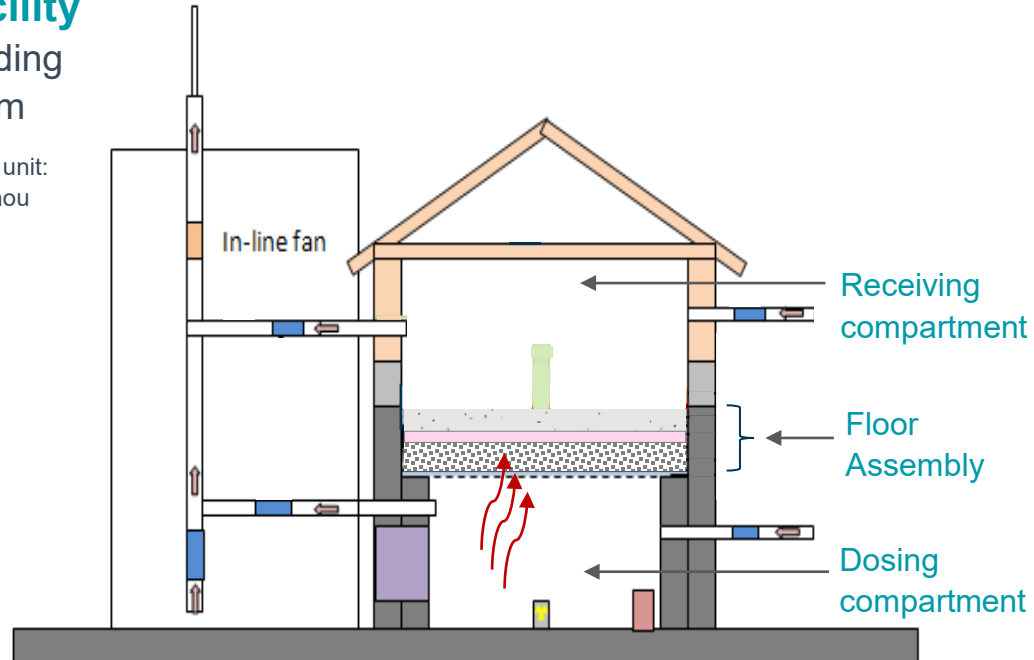


Interior view

RIBETS – NRC facility

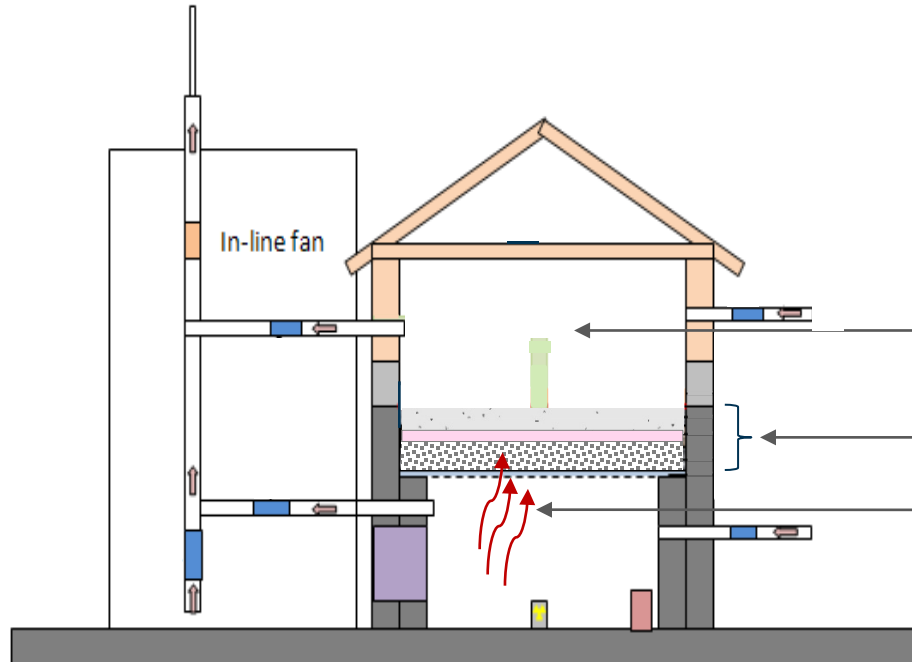
Radon Infiltration Building Envelope Tests System

Building Performance and Quality unit:
NRC lead researcher Dr. Liang Zhou



Conceptual design of the RIBETS

Radon infiltration (NRC facilities)



Conceptual design of the RIBETS

Property	Performance
$\frac{\text{Radon receiving}}{\text{Radon dosing}}$	19.8% (XPS) – better performance 37.6 % (poly)

Receiving compartment

XPS floor: Rn concentration 720-840 Bq/m³

Poly floor: Rn concentration 1300 Bq/m³

Floor Assembly

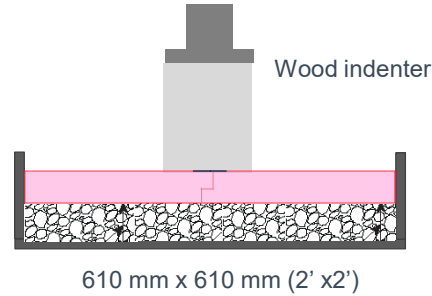
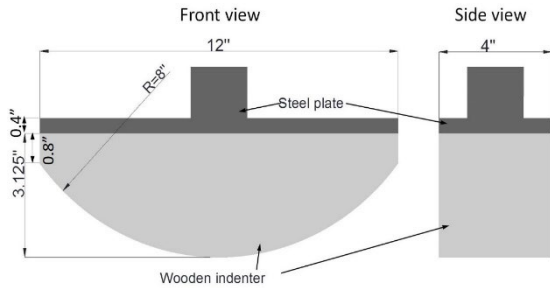
Dosing compartment

XPS floor: Rn concentration 3800-4200 Bq/m³

Poly floor: Rn concentration 3400 Bq/m³

Evaluation – XPS foam panels system

3. Mechanical damage resistance and penetration in gravel



XPS foam panel with joints and tape
50 mm clean gravel (repeat with 3/4 in., 1/2 in. and 1/4 in.)

610 mm x 610 mm (2' x 2')

Compressive load
2 kN
applied with wooden indenter

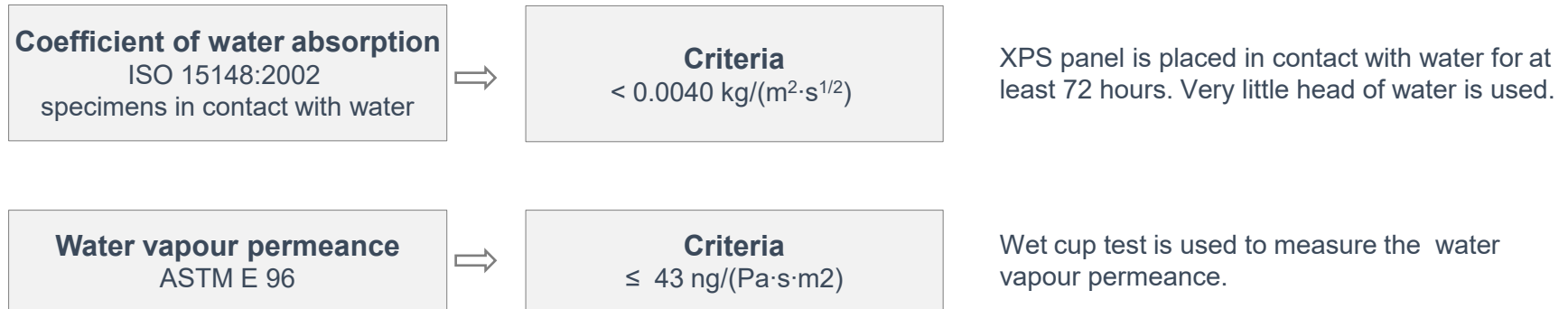


Criteria

- Foam integrity is maintained
- Verify depth of penetration in gravel
- Verify RDTC diffusion data

Evaluation – XPS foam panels system

4. Dampproofing characteristics (optional)



Not an alternative to NBC dampproofing solution

Evaluated gas permeable layer

Product description

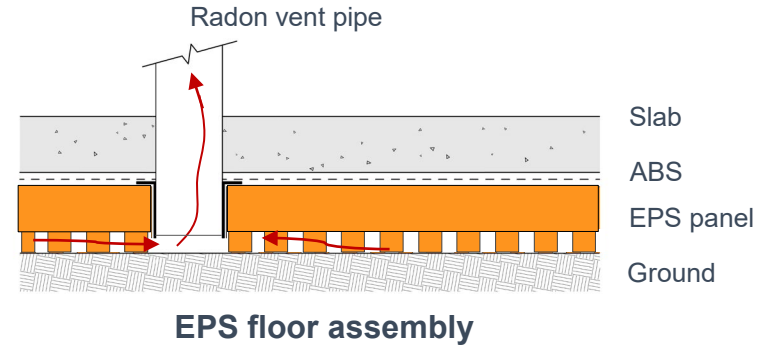
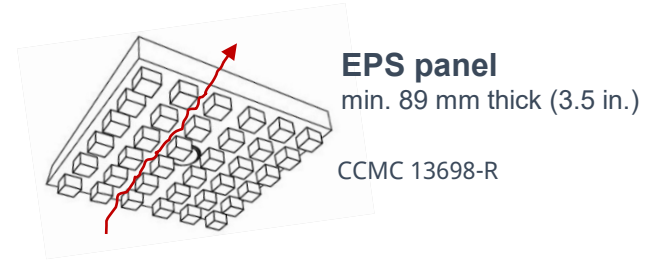
- EPS type 2 and type 3

Main function

- Impermeable layer that dissipates soil gas through interconnected channels

Conditions and limitations – Part 9

- Air barrier assembly required (continuous and sealed)
- Over undisturbed soil, compacted fill or a sand base
- Dry service conditions
- Inlet/outlet



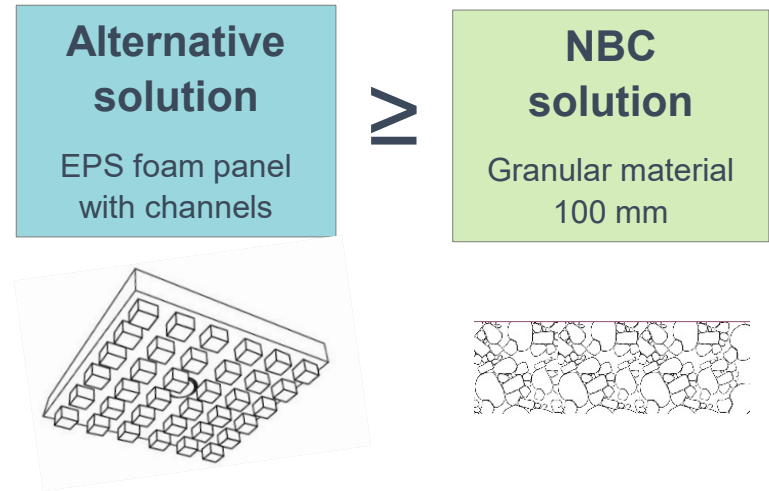
CCMC Technical Guide for Gas Permeable Layer

Testing protocol

1. Materials qualification
 - Basic properties (standard CAN/ULC-S701)
2. System performance (floor assembly)
 - Preliminary test: Radon gas (Rn) infiltration through floor assembly
 - Performance test: Sub-slab depressurization communication to vent pipe

NRC – RIBETS test

System evaluation



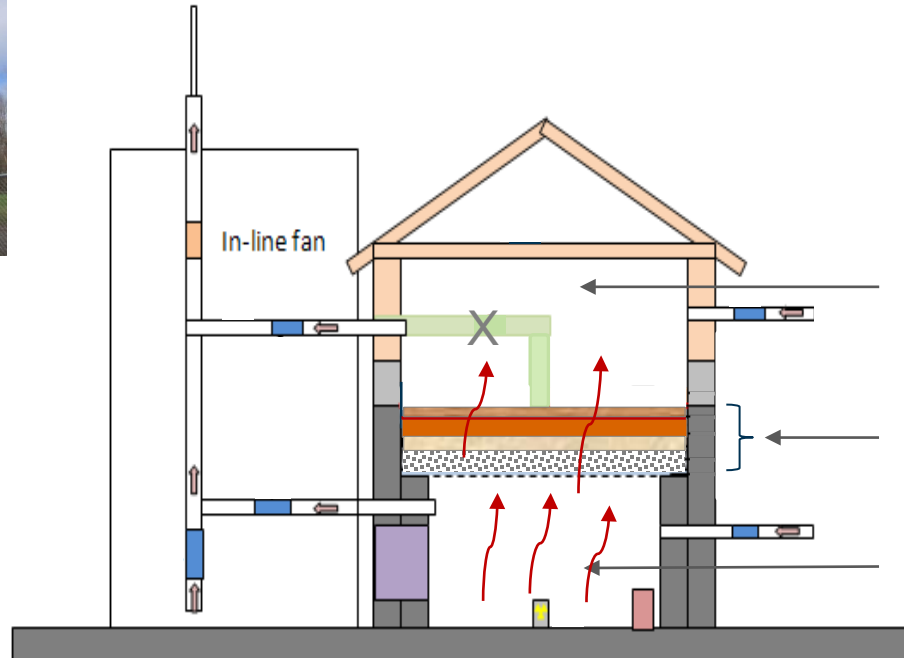
Preliminary testing

Radon gas (Rn) infiltration through the floor assembly



RIBETS – NRC facility for testing soil gas control system

No exhaust vent pipe activated



Receiving compartment

EPS: Rn concentration 50 Bq/m^3

Gravel: Rn concentration 36 Bq/m^3

Floor assembly

EPS: Sand + EPS + ABS + floor panels

Gravel: 100 mm gravel + ABS + floor panels

Dosing compartment

EPS: Rn concentration 4500 Bq/m^3

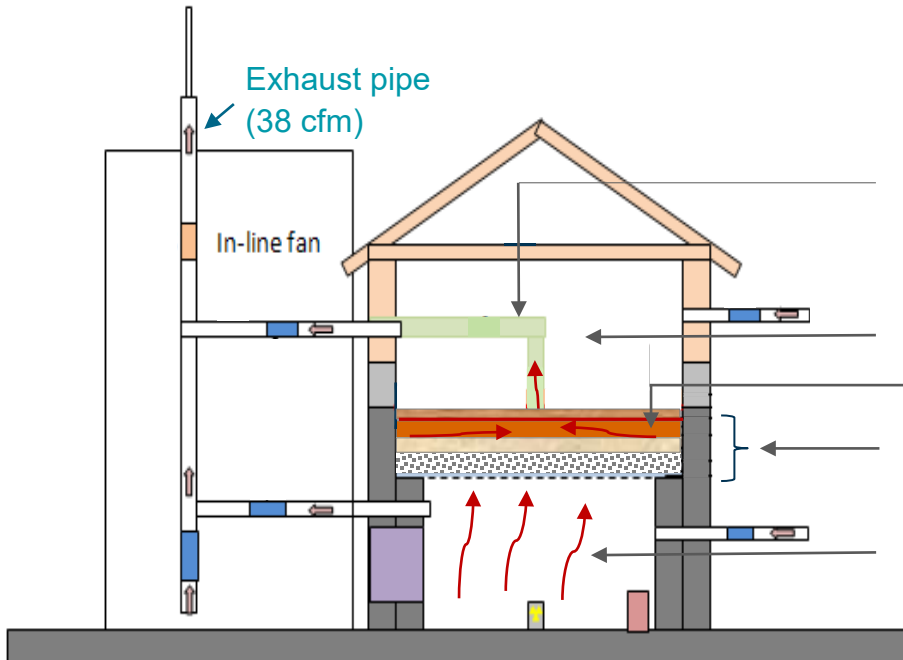
Gravel: Rn concentration 4200 Bq/m^3

Conceptual design of the RIBETS

Performance test

Sub-slab depressurization communication test

Exhaust vent pipe activated



Property	Performance
Negative pressure induced and maintained	EPS channels = 100 mm gravel

Ventilation system

Receiving compartment

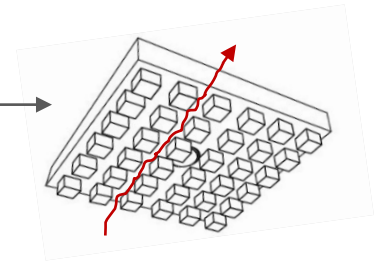
EPS: Pressure -8.3 Pa
Gravel: Pressure -7.3 Pa

Floor assembly

EPS channels: Pressure -1.7 Pa
Gravel: Pressure -1.4 Pa

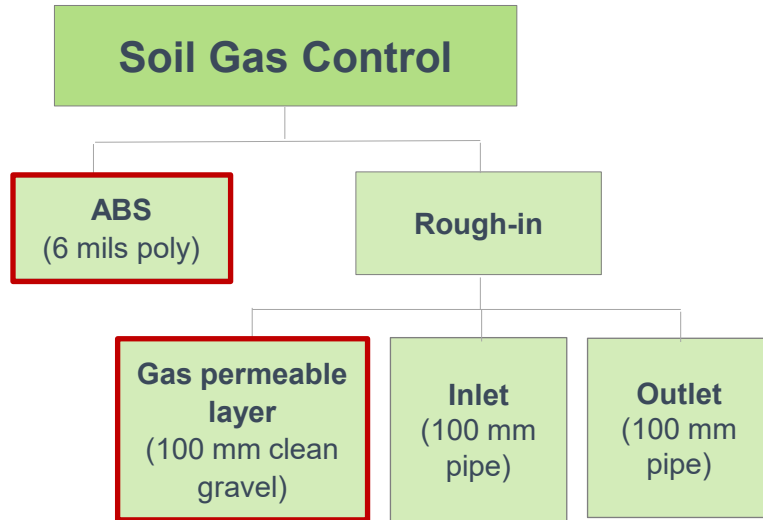
Dosing compartment

EPS: Pressure -28 Pa
Gravel: Pressure -29 Pa



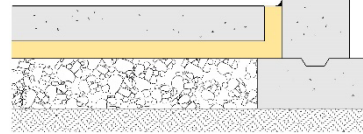
Summary

NBC Soil gas control and CCMC evaluations



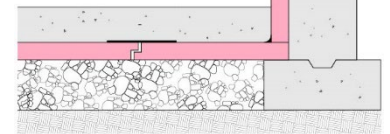
Spray foam insulation

CCMC 14152-R
CCMC 14280-R
CCMC 14445-R



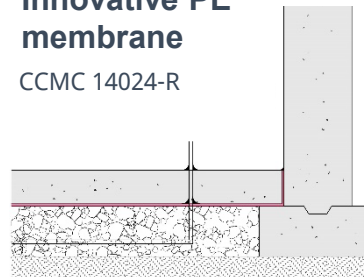
Polystyrene (XPS) panel insulation

CCMC 14349-R



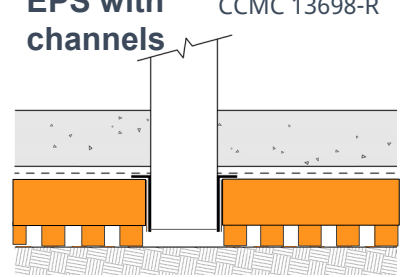
Innovative PE membrane

CCMC 14024-R



EPS with channels

CCMC 13698-R



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