Evaluation Report CCMC 14073-R
CUFCA Radon Mitigation System (RMS™)

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1. Opinion

It is the opinion of the Canadian Construction Materials Centre (CCMC) that "CUFCA Radon Mitigation System (RMS™)," when used as a soil gas (radon) barrier in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code (NBC) of Canada 2015:

- Clause 1.2.1.1.(1)(a) of Division A, as an acceptable solution from Division B:
  - Sentence 9.13.4.2.(1), Protection from Soil Gas Ingress (Air Barrier System for Floor Assemblies)

- Clause 1.2.1.1.(1)(b) of Division A, as an alternative solution that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:
  - Sentence 9.25.3.6.(1), Air Barrier Systems in Floors-on-ground (6-mil polyethylene)

This opinion is based on CCMC's evaluation of the technical evidence in Section 4 provided by the Report Holder.

2. Description

2.1 Proponent

The proponent for this "system" evaluation is the Canadian Urethane Foam Contractors Association (CUFCA) in conjunction with their member spray foam manufacturers that designate CUFCA-trained installers to install the manufacturer's finished product (i.e., CAN/ULC-S705.1-compliant spray polyurethane following CAN/ULC-S705.2. For this evaluation, CUFCA requested CCMC to develop the qualification requirements to the NBC as an alternative solution, undertook the testing on their member manufacturer's products and led the development of the field quality assurance program (FQAP) for the proprietary CUFCA RMS™.

2.2 System Components

The system components in the proprietary CUFCA RMS™ are specific CAN/ULC-S705.1-compliant spray polyurethane foams (SPUF) that have met the CCMC requirements below and are site-manufactured by CUFCA RMS™-trained installers. The current CUFCA RMS™-qualified spray polyurethane foam (medium-density) insulations are CCMC 13244-L (Demilec Heatlok/Airmetic/Polarfoam SOYA) and CCMC 14025-L (Genyk Boreal Lavender/Nature).

2.3 Installer Training and Field Quality Assurance Program (FQAP)

The CUFCA RMS™-trained installers are specifically trained in accordance with CUFCA's RMS™ Training and Installation Manual, dated October 1, 2017, and are subject to audits following the CUFCA FQAP, dated September 13, 2017. Note that CUFCA RMS™ training program and installer certification to install the RMS™ is in addition to the base CUFCA training for the spraying of polyurethane foam as an insulation **only**, in accordance with CAN/ULC-S705.2. For the installation of the CUFCA RMS™ system, the CUFCA installer must have a CUFCA identification card to present to the building official that indicates the installer is CUFCA-certified to install the spray foam for both intended functions, i.e., insulation (CAN/ULC-S705.2) and air/radon barrier (CUFCA RMS™).

2.4 Thickness – Spray Foam and Gravel Drainage Layer

The CUFCA RMS™ requires a minimum of 50 mm spray polyurethane to be installed. The spray polyurethane may be sprayed directly over the NBC-specified 100-mm gravel bed or onto a geotextile. When applied directly over the gravel bed, the foam resin may penetrate up to 12 mm penetration into the cavities between surface gravel. For direct gravel applications, the gravel bed shall be increased to 112 mm to ensure a minimum 100-mm gravel bed as the gas-permeable layer to evacuate the radon gas.

2.5 Radon Resistance

It should be noted that Sentence 9.13.4.2.(1) of the NBC requires an effective air barrier system be installed as a barrier to soil gas. The CUFCA RMS™ has been evaluated beyond the NBC qualification as an air barrier system required by Code for soil gas, as outlined in Section 5 of this Report, as the CUFCA RMS™ has qualified as an effective barrier to specifically radioactive radon. The CUFCA RMS™, when installed at 50 mm, shows better resistance to radon than 6-mil polyethylene (i.e., the NBC benchmark acceptable solution).

3. Conditions and Limitations

CCMC's compliance opinion in Section 1 is bound by the "CUFCA Radon Mitigation System (RMS™)" being used in accordance with the conditions and limitations set out below.

- The CUFCA RMS™ system must be applied on-site by qualified installers trained and certified by the CUFCA and who possess the CUFCA RMS™ identification card.**(1)** The CUFCA RMS™ Training and Installation Manual shall be available on-site for review by the local authority having jurisdiction (AHJ).
- The spray polyurethane foams must be CCMC 13244-L (Demilec Heatlok/Airmetic/Polarfoam SOYA) or CCMC 14025-L (Genyk Boreal Lavender/Nature).
- The thickness of the specified medium-density spray polyurethane foam shall be a minimum of 50 mm (2 in.) when installed over geotextile. When sprayed directly onto the gravel, the NBC-specified 100-mm gravel bed shall be increased to 112 mm.
- A minimum of 24 hours shall pass before the installation of the 100-mm concrete floor slab.
- As with the 6-mil polyethylene sheet, care shall be taken to not damage the spray polyurethane surface during the installation of the concrete slab, in particular, any reinforcement mesh.
- The CUFCA RMS™ has shown ability to seal around penetrations of 100-mm ABS and steel pipes without need for sealant. Other materials may require additional sealant (i.e., polyethylene pipe).

1. Periodic CUFCA audits of the installer are conducted. The CUFCA policy is to conduct occasional random inspections and mandatory inspections of larger projects. Building officials may contact CUFCA (1-866-GO-SPRAY) and require an inspection for a specific job site if the building official deems it necessary.

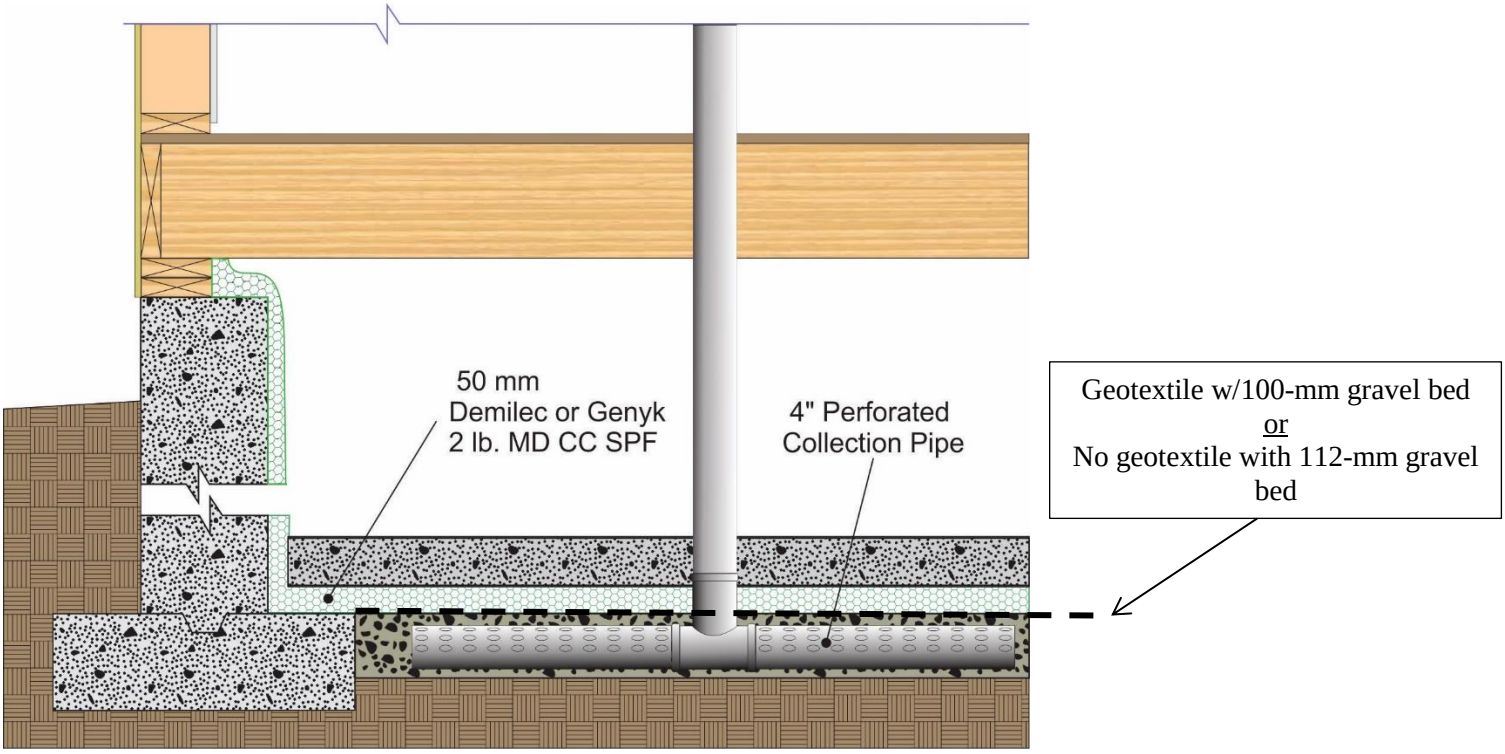

Figure 1. Application of CUFCA RMS™ beneath concrete slab, with geotextile/100mm gravel or without geotextile/112mm gravel bed.

4. Technical Evidence

The Report Holder has submitted technical documentation for CCMC's evaluation. Testing was conducted at laboratories recognized by CCMC. The corresponding technical evidence for this product is summarized below.

4.1 Performance Requirements

The following were the key performance requirements for the evaluation:

1. **Material Qualification:** Medium-density SPUF, complying with CAN/ULC-S705.1 and installation as per CAN/ULC-S705.2. Confirmed through possession of active CCMC Listing;
2. **Air Barrier System:** The air barrier system for floors-on- nd qualification though testing. The NBC benchmark is 6-mil polyethylene as per Sentence 9.25.3.6.(1) of the NBC;
3. **Soil Gas Barrier:** The soil gas, specifically radon, barrier performance based on qualification testing, small-scale and large-scale. The NBC benchmark is 6-mil polyethylene as per Sentence 9.13.4.2.(1), Protection from Soil Gas Ingress, of the NBC, referring to Sentence 9.25.3.6.(1);
4. **Resistance to Mechanical Damage:** Repeat small-scale radon barrier testing with indented SPUF by simulated concrete pour/workman load damage.
5. **Dampproofing:** The dampproofing function as a requirement for the SPUF beneath the slab is optional as dampproofing is waived when 100 mm coarse, clean granular material is installed beneath the slab as per Clause 9.13.2.1.(3)(c), Required Damproofing, of the NBC. See Optional Testing in Section 5.1.1 of this Report.

Table 4.1.1 Material Qualification

SPUF Product CAN/ULC-S705.1 Compliance	Insulation in Field (CAN/ULC-S705.2) Field Quality Assurance Program (FQAP)	Radon Barrier in Field CUFCA RMS™ Field Quality Assurance Program (FQAP)
CCMC 13244-L (Demilec Heatlok/Airmetic/Polarfoam SOYA)	CUFCA trained and certified installers	CUFCA RMS™ trained and certified installers
CCMC 14025-L (Genyk Boreal Lavender/Nature)	CUFCA trained and certified installers	CUFCA RMS™ trained and certified installers

Table 4.1.2 Air Barrier System Performance

Material	Test Procedure	Requirement	Result
SPUF products CCMC 13244-L and CCMC 14025-L sealing around pipe penetrations[(1)]	ASTM D 2178/D 2178M-13[(1)]	0.02 L/(s·m^2) (see Note[(2)])	.0011 – .0075[(3)]
6-mil polyethylene	NBC Table A-9.25.5.1.(1)	NBC acceptable solution benchmark	negligible

Notes to Table 4.1.2:

1. The tested 1 m × 1 m specimens of 50 mm thick SPUF contained a 100-mm-diam ABS pipe and a 100-mm steel pipe to verify the SPUF sealing to elements that may penetrate the CUFCA RMS™ in the field. The 6-mil polyethylene with a pipe penetration and tape/sealant was not tested.
2. The derivation of the criterion is based on the permitted air leakage of a fixed window per length of seal/joint (i.e., 0.068 L/s/m). The circumference of the 100-mm pipe is 319 mm resulting in a criterion of 0.319 m × 0.068 l/s/m = 0.0217 L/s.
3. Although this air leakage performance is not as low as negligible for 6-mil polyethylene sheet without a pipe penetration, this air leakage performance is extremely low. This testing used air as the medium to compare SPUF to 6-mil polyethylene, the comparison below using radioactive radon (Rn) gas as the medium for comparison is the key performance indicator for evaluating/comparing the performance as a barrier to radon gas.

Table 4.1.3 Radon Barrier Performance

Material	Test Procedure	Requirement	Result
Small-scale Tests			
SPUF products CCMC 13244-L and CCMC 14025-L at 50-mm thickness	NRC Radon Diffusion Test Chamber (RDTC) (see Appendix A for schematic of test apparatus)	Radon Diffusion Coefficient of alternative solution < benchmark	neglible[(1)]
6-mil polyethylene (NBC benchmark)			1.12×10^{-11} (m^2/s)
After mechanical damage: SPUF products CCMC 13244-L and CCMC 14025-L at 50-mm thickness			neglible[(1)]

Large-scale Tests			
SPUF products CCMC 13244-L and CCMC 14025-L	NRC Radon Infiltration Building Envelope Test Systems (RIBETS) (see Appendix A for schematic of test facility)	Radon Infiltration through CUFCA RMS™ and floor assembly as an alternative solutions (RnR/RnD)[2] < benchmark	2.0
6-mil polyethylene (NBC benchmark)			6.6

Notes to Table 4.1.3:

1. The radon diffusion coefficient for the SPUF products could not be obtained since no significant amount of radon diffused through the SPF samples during the radon diffusion tests. Therefore, the SPUF at 50-mm thickness is better than the 6-mil polyethylene benchmark as barrier to radon (Rn) in this small-scale test.
2. The radon (Rn)-measured levels ratio (Rn_R/Rn_D) is for comparison of the alternative solution to the benchmark acceptable solution. The numerator with subscript 'R' represents the radon in the receiving chamber. Therefore, the SPUF at 50-mm thickness is better than the 6-mil polyethylene benchmark as barrier to radon (Rn) in this large-scale test that is representative of the installation the field.

5. Other Technical Evidence

5.1 Additional Performance Data Requested by the Report Holder

Data in this section does not form part of CCMC's opinion in Section 1.

5.1.1 Dampproofing (Optional)

Table 5.1.1.1 Dampproofing Performance of SPUF[1][2]

Property	Test Procedure	Requirement	Specification
Coefficient of water absorption @ 24-h[1] kg/($m^2 \cdot s^{1/2}$)	ISO 15148:2002	< 0.0040	0.0011
Water vapour permeance[2]	ASTM E 96/E 96M, Procedure B (wet cup method)	≤ 43 ng/(Pa·s·m^2)	60.4[3]

Notes to Table 5.1.1.1:

1. Minimum 24 hours as per ISO 15148:2002, "Hygrothermal performance of building materials and products – Determination of water absorption coefficient by partial immersion." The criterion has been met which demonstrates that the polyurethane surface provides good water resistance.
2. The ASTM E 96/E 96M-13, "Water Vapor Transmission of Materials," specimens were selected from three (3) 1 m × 1 m sprayed panels, 50 mm thick and tested with skins removed.
3. The criterion specified in Clause 9.13.2.2.(2)(b), Dampproofing Materials, of the 2015 NBC, has not been met at the 50-mm thickness with skins removed. When the polyurethane is required to serve as dampproofing, the thickness shall be increased proportionally (i.e., add: [(60.4-43)/60.4] × 50 mm = 14.1 mm).

Report Holder

Canadian Urethane Foam Contractors Association (CUFCA)
3200 Wharton Way
Mississauga, ON L4X 2C1

Telephone: 1-866-467-7729
Fax: 1-877-416-3626
E-mail: cufca@cufca.ca

Web site: www.cufca.ca

Plant(s)

Demilec Inc., Boisbriand, QC
SOLUTIONS Genyk, Grand-Mère, QC

Disclaimer

Date modified:
2017-11-01

Appendix A - NRC Construction Radon Testing Facilities

1) Small-scale Tests
   Radon Diffusion Test Chamber (RDTC)

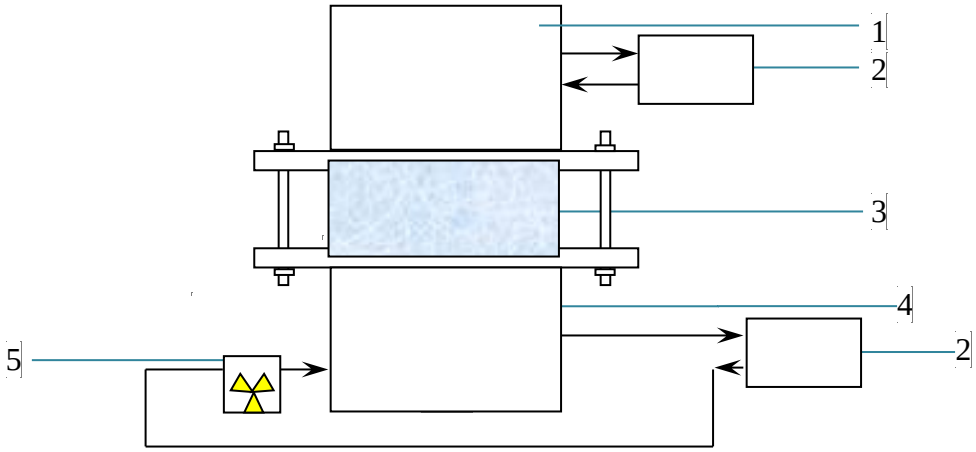

Figure A1: Schematic of RDTC

1. **Receiving compartment**
2. **Radon monitor**
3. **Test sample**
4. **Dosing compartment**
5. **Radon source**

2) Large-scale Tests
Radon Infiltration Building Envelope Test Systems (RIBETS)

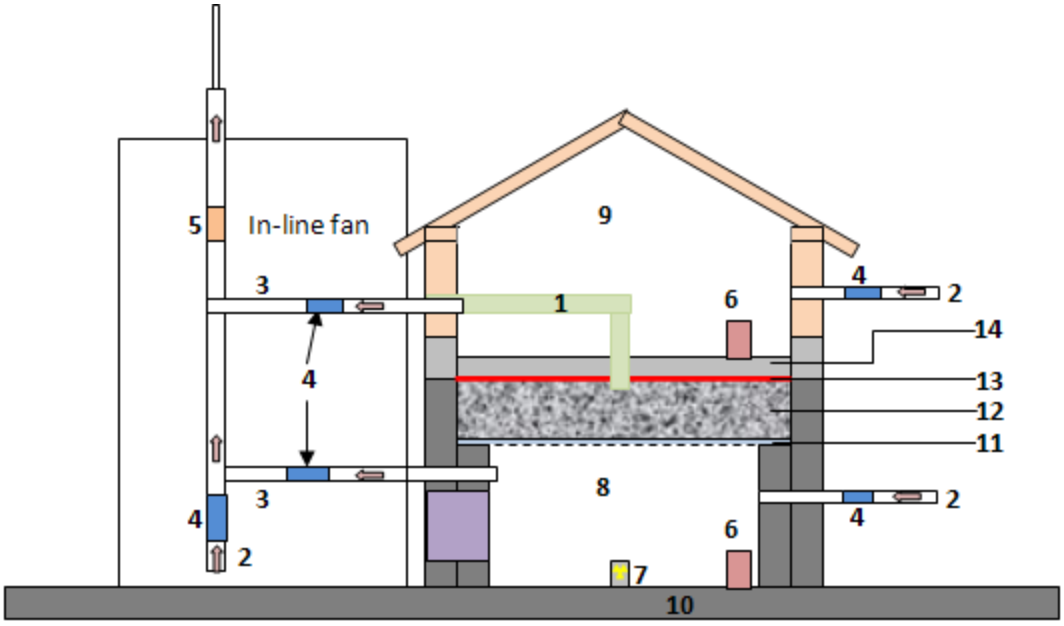

Figure A2. Conceptual design of the RIBETS

1. **Sub-slab radon (Rn) exhaust stack**
2. **Make-up air stack**
3. **Exhaust stack**
4. **Control damper**
5. **In-line fan**
6. **Baseboard heater**
7. **Radon (Rn) source**
8. **Dosing compartment**
9. **Receiving compartment**
10. **Concrete pad**
11. **Perforated stainless steel plate**
12. **Gravel (100 mm/4 in.), specification as per NBC**
13. **Air barrier (6-mil polyethylene or spray foam products)**
14. **Concrete slab (101.6 mm/4 in.)**