December 13, 2020
Technical Bulletin #402

Subject: Radon Control Layers for Retrofit Applications

Closed-Cell Spray Polyurethane Foam: Better, Faster, Less Expensive

The Situation

Boreal Elite closed-cell spray polyurethane foam (ccSPF) is an exceptional radon control layer. The product is laboratory tested by the National Research Council (NRC), reviewed by the Canadian Construction Materials Centre (CCMC), and most importantly, a mainstream staple of new construction installations. Using *Boreal Elite* as a control layer solution is obvious – it absolutely performs. However, until recently, the benefits of the product were limited to new construction slab-on-grade and foundation wall solutions.

The application flexibility of ccSPF allows for a greater range of installation solutions. Specifically, providing a radon control layer to retrofit applications. The traditional approach of using membranes to provide a radon control layer is labour intensive, and often, not possible because of irregularity of surfaces, foreign objects, and access limitations. Solving issues specific to crawl space installations has led Genyk to test *Boreal Elite* in the most challenging crawl space applications.

The Research

Given that NRC has already established the radon control layer properties of *Boreal Elite* ccSPF (Appendix A), the goal of the Retro-Radon project was to demonstrate crawl space installation solutions provided by a *Boreal Elite* ccSPF. Similar to ccSPF, radon membrane installations are absolutely achievable in new construction situations. Access to work areas and flat surfaces allow for a seamless installation.

New construction membrane installation

New construction Boreal Elite installation

This study focuses on areas of challenge faced by traditional membrane installation. To that end, the crawl space selected for testing encompassed the most difficult situations available. Comparisons between membrane and ccSPF installation methodology includes three specific areas of concern –

1. Accessibility
2. Surface irregularity
3. Wall / floor continuity

There are other challenges encountered when installing a radon control layer in a crawl space; however, focussing on the primary causes of concern provides insight into the ccSPF solutions available.

The research data was achieved using a significantly difficult crawl space application. An existing crawl space with some areas limited to eighteen-inch clearance, a dirt floor, exposed root systems and existing appliances was selected to ensure that the collected data provided solutions to commonly experienced situations. The testing process included –

1. Pre-testing the crawl space to achieve a radon start point. Even though the performance of *Boreal Elite* as a radon control layer has been previously established by NRC testing, a radon test was performed to verify improvement after the spray foam installation.
2. Installing 50mm of *Boreal Elite* to the floor and walls of the crawl space. Even though the majority of the walls were above-grade, the installation was done to mimic the very difficult wall/floor junction (in crawl spaces).
3. A post-test was done to ensure the performance of the *Boreal Elite* installation.

The Genyk Project

Health Canada mandates immediate remediation when homes test radon levels greater than 200 Bq/m^3 (5.41 pCi/L). The recommended level of remediation is 75 Bq/m^3 (2.03 pCi/L). While the case study crawl space was selected for installation difficulty rather than elevated radon levels, the crawl space did demonstrate higher than average radon levels.

Note: typical levels of radon in occupied homes is 40 Bq/m^3 (1.08 pCi/L).

The thirty-day, pre-remediation radon test demonstrated a level of 66 Bq/m^3 (1.78 pCi/L).

The thirty-day, post-remediation radon test demonstrated a level of 57 Bq/m^3 (1.54 pCi/L).

The 14% improvement is significant because this is a project that was limited to one radon control layer solution – *Boreal Elite* closed-cell spray foam. Greater improvements are anticipated if pre-existing levels had been higher. That is, the 57 Bq/m^3 level is consistent with complete remediation, and thus, represents a number achievable even with significantly higher pre-remediation levels.

Simply put, large areas were not accessible to a traditional membrane application. Membranes could not have been fastened at the floor / wall junction. Roots and rocks would have created large air pockets under the membranes and would have created constant movement, and eventually, mechanical damage. Further, the presence of mechanical equipment necessitates lifting in order to ensure the continuity of the membranes – labour intensive, expensive and not necessarily physically possible.

Accessibility

The crawl space tested was selected because of the existence of several accessibility issues. The North/South slope ranged from eighteen inches at the North elevation to seventy-two inches of clearance at the South elevation. The span (from exterior wall to areas greater than eighteen inches) ranged between twenty-four and thirty-six inches. Obviously, the adhesion of membranes to the exterior walls in these areas would, at best, be labour intensive. At worst, gaps where the membrane was not correctly installed would allow radon gases to enter the crawl space.

Further, ensuring continuity of the radon control layer on the floor would be left to probability rather than certainty because of the inability to visually confirm the application. Similarly, the solution to providing a monolithic control layer under appliances was only possible with the 'bulk-fill' ability of ccSPF. The water heaters in the case study had clearances of ten inches and 3 inches respectively.

(the furnace was six inches, not shown). Installing membranes to these areas without removal would be impossible. But with ccSPF, the process was not only attainable but was done so quickly and with certainty.

Areas of limited clearance – wall/floor junction less than eighteen inches

BEFORE - Clearance issues below water tanks

AFTER – Complete seal under appliances

Surface Irregularity

Although membranes can survive any of unlevel surfaces, rocks, roots and other protrusions, the reality is that any of the before mentioned situations can cause membrane failure. Foot traffic on membrane that has been installed over uneven surfaces can puncture the membrane. If unnoticed and unrepaired, the compromised membrane is essentially useless as a radon control layer.

Boreal Elite ccSPF is a permanent control layer. The spray foam is installed under, around and on top of irregular surfaces. Rocks and roots are embedded in the spray foam, and thus, are prevented from puncturing the control layer. ccSPF has excellent adhesion to auxiliary substrates like wood, steel, ABS and rock. This adhesion allows for a monolithic application. Because the installation is free of mechanical fasteners, sealants and secondary detail materials that typically fail over time, the *Boreal Elite* radon solution is permanent.

Before/After - ccSPF installed over rocks and root systems

Boreal Elite has a compressive strength of 228 kPa (33 psi). The material easily overcomes foot traffic. Further, when installed at 50mm (2 inches) or more, even unlikely damage to the surface material will not affect the performance of the assembly. ccSPF is an air (gas) barrier at thicknesses much less than the specified 50mm associated with the Genyk Radon Control Layer system.

Wall / Floor Continuity

Even self-adhesive membranes require mechanically fastening at the wall/floor junction. However, when clearance is limited to eighteen inches or less, and the span of reach is greater than twenty-four inches, succeeding with a proper installation of membrane is virtually impossible. There will be gaps if the self-adhesive is not complete. Similarly, if the fastening bar is not properly affixed to

the wall junction, gaps and penetrations will be present. Obviously, the entire purpose of a radon control layer is continuity. Even the smallest penetration will allow radon to penetrate the assembly. Fastening bars are prone to wear. Especially if not installed correctly. Given access limitations, the mechanical seal that is necessary to ensure the continuity of membranes is often not possible. At a minimum, the fasteners will not be installed to specification. An incomplete, or improper installation facilitates future breakdown. Any and all gaps in a radon control layer result in access of the gas into the living space.

BEFORE – Clearance, protrusions and unreachable wall/floor junction

Further, ensuring continuity of the radon control layer on the floor would be left to probability rather than certainty because of the inability to visually confirm the application.

Boreal Elite ccSPF solves both the floor / wall junction and the continuity of the radon control layer with relative ease. Spray foam can be sprayed thirty-six inches away from the substrate. Not only can the wall be completely sealed, because the floor level control layer is installed from the wall towards the sprayer – all applications can be visually observed during installation.

AFTER – complete seal with Boreal Elite ccSPF

Auxiliary Benefits

"Traditional vented crawlspaces are often damp, mouldy and inhabited with pests. They have almost universally been found to be well connected to indoor air through many small unintentional air leaks in the floors, partitions, and ducts. Therefore, to ensure both durability and indoor air quality (and save energy), a crawlspace must be kept dry, conditioned to control temperature and humidity, and sealed tight to be pest free." Info-512, Building Science Corporation, June 18, 2015

Every research project reveals or confirms additional data. The Genyk Retro-Radon project reinforced the moisture resistance of ccSPF and demonstrated the performance of ccSPF as an effective deterrent to rodents and pests.

Moisture Control

High humidity levels in the crawl space led to wood rot, structural damage, and an increased risk of insect infestation. The ideal crawl space humidity level is between 30% and 50%; the ideal living space humidity level is between 35 and 45%. However, many homes have crawl spaces with relative humidity levels above 60%. High crawl space humidity levels can lead to various problems, and it is important to reduce humidity levels in your crawl space.

The case study crawl space had pre-foam levels exceeding 60% (62% at the start of the initial 30 day radon test, 65% at the 30-day mark). Subsequently, the occupied living area above had

correspondingly high humidity levels (50% plus on average). A significant reduction in crawl space and occupancy humidity levels is not surprising because of *Boreal Elite's* excellent vapour permeance properties. ccSPF is well known for being a vapour barrier, and when sprayed in a 50mm monolithic layer, the benefits of moisture protection are immediate:

Prior to spray foam control layer -	> 60% relative humidity in crawl space
Prior to spray foam control layer -	> 50% relative humidity in living area
Post spray foam control layer -	< 55% relative humidity in crawl space
Post spray foam control layer -	< between 40 and 50% relative humidity in living area

Rodent and Pest Control

In this study, performance related to rodent and pest control is entirely empirical. However, the case study homeowners have acknowledged that previous to the spray foam control layer, the presence of insects, spiders and mice was significantly more pronounced. Predictably, providing a complete seal of the wall and floor has had a substantial impact on the ability of insects and rodents to access the crawl space area.

Energy Efficiency

Undoubtedly, ccSPF provides the end-user with a radon control layer that is, at a minimum, equivalent to any membrane product. Beyond the radon protection, *Boreal Elite* also provides energy efficiency to areas that are historically overlooked as a critical component of the building envelope. A typical retrofit insulation project includes insulating the walls of the crawl space and 'conditioning' the volume of air within the crawl space. Without the floor insulation, this methodology is inefficient. Similarly, insulating the floor of the occupied space above the crawl space is both expensive, and often, detrimental to the condition of the wood structural components (the moisture within the crawl space can accumulate in the wood).

Insulating the floor and walls of the crawl space eliminates air infiltration and reduces energy loss. The result is a more comfortable floor area and energy efficiency.

Conclusions

The NRC test results along with the CCMC assessment of those results makes ccSPF a logical choice for radon control layer protection in new construction. And the performance characteristics confirmed by CCMC points to the likelihood that ccSPF will perform in every radon control layer application.

This case study affirmed that claim. Spraying 50mm to the floor and walls of a crawl space reduced existing radon levels by 14%. Given that the pre-existing radon levels were not exceedingly high, this reduction is significant. But what is missing in the raw data is the obstacles that a spray foam installation overcame.

- ✓ Spray foam can achieve a radon control layer in areas previously considered unattainable. Low clearances and hidden voids can be filled with ccSPF
- ✓ ccSPF does not require fastening bars. In crawl spaces, fasteners are difficult to impossible to install. Spray foam reaches the areas that fasteners cannot
- ✓ ccSPF provides a monolithic layer of radon protection that also serves as a vapour barrier. Moisture issues that are commonly associated with crawl spaces are eliminated. Dry rot, high indoor humidity, window condensation are some of the benefits that come with a high-end radon barrier
- ✓ The air/vapour/gas seal associated with ccSPF also mitigates the intrusion of insects and vermin. A well-sealed crawlspace eliminates many of the entrance points for unwanted pests
- ✓ ccSPF has always been the most efficient of insulations. In addition to providing a radon control layer, the product will also enhance indoor air quality, comfort, and energy efficiency

APPENDIX A – CCMC 14445-R

Complete report available at –

https://nrc.canada.ca/en/certifications-evaluations-standards/canadian-construction-materials-centre/ccmc-publications/pdf

CCMC CANADIAN CODE COMPLIANCE EVALUATION

CCMC 14445-R

CCMC Canadian code compliance evaluation

CCMC number:	14445-R
Status:	Active
Issue date:	2023-02-17
Modified date:	2023-11-08
Evaluation holder:	**SOLUTIONS Genyk Inc.** 1701 3rd Avenue Shawinigan QC G9T 2W6 Canada Website: www.genyk.com Telephone: 819-729-0395 Email: info@genyk.com
Product name:	Boreal Nature Elite - Radon Mitigation System
Compliance:	NBC 2015, OBC
Criteria:	CCMC-TG-072623.01-15, "CCMC Technical Guide for Medium Density (MD) Spray Polyurethane Foam Insulation (SPUF) for Soil Gas (Radon) Control beneath Concrete Slabs-on-Ground"

In most jurisdictions this document is sufficient evidence for approval by Canadian authorities.
Learn more about CCMC recognition Look for the trusted CCMC mark on products to verify compliance.

APPENDIX B – RADON TEST REPORT

Alder Creek Inspections and Consulting
1093 Bleams Road
Petersburg ONT N0B 2H0
519-742-1114 / 519-590-8466 (cell)
www.aldercreekinspections.com / tom.weber@bellnet.ca

Radon Test Report

October 15, 2024
Batch #: 062424-1

Customer:
Mike Richmond
Bancroft

Test Site:
Mike Richmond
Bancroft

E-PERM® Electret Ion Chambers were used for short-term radon screening measurements that were conducted at the above referenced test site by: Alder Creek Inspections and Consulting

The Results are as follows:

Serial No.	Type	Location	Test Start Date	Test End Date	Results (Bq/m³)
SGR408	SST	Basement	30-Jun-2024 2:58 PM	01-Aug-2024 11:04 AM	67 Pre
SGR507	SST	Basement	28-Aug-2024 4:30 PM	29-Sep-2024 6:08 PM	63
SGU474	SST	Basement	28-Aug-2024 4:30 PM	29-Sep-2024 6:08 PM	57 Post

Deployed By: Tom Weber CRT 201736
Retrieved By: Tom Weber CRT 201736
Analyzed By: Tom Weber CRT 201736 **Reader S/N:** E1183 **Reader Calibration Due:** 20-Nov-2024
Conditions: Requirements for Closed-Building Met
Vents: Closed / Fan Not Applicable
Mitigation: No System Installed
Comment: #474 and #507 are tests from post spray foam floor covering / Client self tested with supplied Electrets from AC

Mike Richmond
Vice President Compliance & Building Science
Genyk