HUNTSMAN
BUILDING SOLUTIONS

August 24, 2020

Object : Under Slab Insulation / Radon – Heatlok HFO PRO

Energy efficiency requirements are constantly increasing in all types of buildings. Many states now require insulation below the basement slab or slab on grade. There are now also requirements to protect the occupant from soil gas like radon in IRC Appendix F.

It is often very complicated and costly to get a perfectly sealed under slab system. Heatlok HFO PRO can provide a quick and simple solution for any under slab insulation. A solution that can be adapted easily to any shape or details of all types of construction. Heatlok HFO PRO can be sprayed directly on crushed stones or dirt to provide a perfectly sealed under slab insulation system. The concrete slab can then be poured directly on the product.

Insulation, Air Barrier and Vapor Barrier Properties

Heatlok HFO PRO is one of the most effective insulation products on the market with an R-Value of R-7.4 per inch. It can be applied to any thickness desired to meet the energy requirements. Due to its continuity and the fact that it is seamless, it also provides a continuous air barrier assembly under the slab and seals any penetration, like plumbing pipes or others without the use of tape or sealant. It has been tested in accordance with ASTM E2178 with an air permeance result of less than 0.02 $l/s\text{-}m^2$ @ a 75 Pa pressure difference. It also provides a Class II Vapor Diffusion Retarder with a result of less than 1 perm at only 1''. No other vapor barrier is required, as 1 ½'' of Heatlok HFO Pro will provide sufficient resistance to vapor.

Heatlok HFO PRO provides all three necessary components for a high performance assembly: an air barrier, a vapor barrier and insulation. This would require 3 or 4 products with other systems. Not only that, the quality of the product and its installation is superior to other systems.

* Note that if a Class 1 Vapor Diffusion Retarder, such as 6 mil polyethylene, is requested, it can be installed on top of the foam before pouring the concrete slab. It should not be installed prior to the spray foam installation.

Radon Barrier

Heatlok HFO PRO is one of the only products to have been tested for radon diffusion. Radon protection is usually provided by an air barrier material, since radon travels primarily through air. However, there can ~~be~~ radon diffusion through some air barrier materials. That is the reason why our product has been tested in accordance with K124/02/95 (method C of ISO/TS 11665-13) for radon diffusion. At only 1'', Heatlok HFO PRO performs 35 times better than 6 mil polyethylene for radon protection. Furthermore, the product is often installed at a thickness of 1 ½ '' to 2'' and is therefore much harder to puncture than 6 mil polyethylene when workers are walking on it during construction.

Our Heatlok Canadian product has also been evaluated by a CNRPP (Radon Specialist) officer in Canada (AARST in the US) and has been characterized to outperform a poly for this application.

Compressive Strength/Durability

As mentioned before, Heatlok HFO PRO can be sprayed directly to gravel or dirt to act as insulation, air barrier, vapor barrier/vapor retarder, < 1 Perm, and radon protection. To add to all of this, the product also has an excellent compressive strength for this type of application.

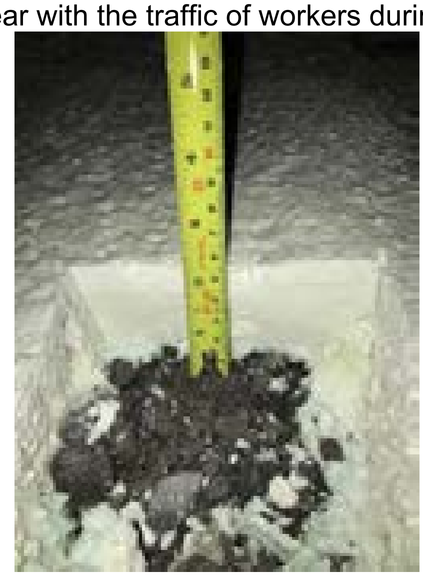
The test method used for compressive strength ASTM D 1621 ''*Standard Test Method for Compressive Properties of Rigid Cellular Plastics'',* is the same for all plastic insulation products on the market.

On the other hand, what is specific to spray polyurethane foams is that they are tested in the core of the foam only. The skin is not included and the reported density is therefore lower. The parameters of the test give conservative results, as these are laboratories conditions. Therefore, the actual overall density on site is always higher than in test conditions, which results in higher compressive performance.

The compressive strength of Heatlok HFO PRO is 31 PSI. As mentioned, the test results are lower than the actual installed density. This compressive strength is in the range of commonly installed products for under slab application.

ASTM D 1621 measures how much force must be exerted to compress the material by 10%. With a compressive strength of 31 PSI (± 4500 lbs per square foot) and considering that the average weight of concrete is 150 lbs per cubic foot, a typical 6" slab of concrete would weigh approximately 75 lbs per square foot. This is well below the structural capability of the foam.

Another advantage of this application is the fact that spray foam will penetrate the crushed stone sub-base for about ½''. The foam when applied is liquid and will penetrate the gravel (see pictures below) to seal everything. At certain areas, there will be more foam and the insulation value will therefore be increased. It makes the assembly very compact without leaving any air space between the insulation and the crushed stone subbase, thus preventing the foam from cracking when walked upon. This is one of the problems of other systems that make them weak and often break or tear with the traffic of workers during construction.



Heatlok HFO Pro is 100% in contact with its substrate making it very solid to walk on. Different thickness can be applied depending on the required R-value. 2'' as demonstrated above is a common application.

Flood Resistance

Many studies and articles have described the exceptional performance of spray foam insulation in coastal areas or hurricane and flood zones. For example, due to its excellent water-resistant properties, closed cell spray foam has received the highest rank (Class 5) by FEMA and NFIP (National Flood Insurance Program) for flood damage-resistant materials. Also it is the only product accepted by FEMA for use as insulation in flood zones. It is very resistant to ground water as demonstrated by its very low water absorption characteristics and its rapid drying capability.

The Canadian Heatlok product was also studied by NRC in Canada for a period of 2 years in a below grade exterior foundation walls applications without additional water proofing and it remained completely dry.

To demonstrate this, during the spring of 2017, there was a major flood in many areas of the Quebec province in Canada. Demilec was involved in a case study with one flooded home where our closed cell spray foam product had been installed years prior. There was about 4 feet of dirty water filling the entire basement. After the water was removed, only the gyprock was taken off and the basement was cleaned with power washers. After the basement was dried for about 5 days, Demilec officials inspected and tested the humidity content of the wall. Only a few small areas still showed a humidity level of more than 15%. In the end, the basement completely dried out and the foam remained in place and only the gyprock needed to be replaced. This saved a lot of time and money for the complete restoration.

Code Compliance Considerations:

2018 IRC Appendix F - Radon Control Methods

Definitions: Soil-Gas-Retarder: A continuous membrane of 6 mil polyethylene or other equivalent material used to retard the flow of soil gases into a building.

Under Slab Vapor Retarder Requirements:

2018 IRC Section R506.2.3 Vapor Retarder

A 6 mil (.006 inch) polyethylene or approved vapor retarder with joints lapped not less than 6 inches shall be placed between the concrete floor slab and the base course or prepared subgrade where a

base course does not exist.

Exception: The vapor retarder is not required for the following:

1. Garages, utility buildings and other unheated accessory structures

2. For unheated storage rooms having an area of less than 70 square feet and carports

3. Driveways, walks, patios and other flatwork not likely to be enclosed and heated at a later date.

4. Where approved by the building official, based on local site conditions.

Note: This section does not require a specific vapor permeance rating but only requires a vapor retarder under the slab. Heatlok HFO Pro, at a thickness of 1” or greater, provides a Class II vapor retarder, 1 perm. Typical thickness of Heatlok HFO Pro when used as a radon barrier under slabs is 1.25” or greater.

Additionally, the section requires that the vapor retarder be lapped 6 inches or greater. For a polyethylene vapor retarder this is important to ensure continuity of both the vapor retarder and the air barrier. Heatlok HFO Pro provides a monolithic continuous air and vapor retarder. Continuity of the air barrier is important because radon enters the space primarily through air gaps or cracks in the slab and around penetrations.

Vapor Retarder vs Vapor Barrier

Prior to 2009, the term “vapor barrier “referred to a material that had a vapor permeance of 1 perm or less when tested using the desiccant method with Procedure A of ASTM E96.
Beginning in 2009, the code defined three levels of vapor retarder classes.

Class I: $\leq$ 0.1 perm rating
Class II: > 0.1 perm to $\leq$ 1.0 perm rating
Class III: >1.0 perm to $\leq$ 10 perm rating
Therefore, a Class II vapor retarder has the equivalent permeance of a vapor “barrier”.

Under Slab Insulation Requirements:

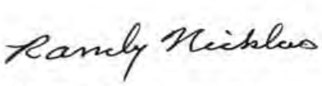
The building code requires various insulation values for slabs on grade (12’’ or less below grade).

In ICC climate zones 1-3 no insulation is required unless the slab is heated. For heated slabs in all climate zones an R-5 is required under the entire slab.
In ICC climate zones 4, 5, 6, 7, and 8, an R-value of 10 is required at the slab edge extending either inward or outward from the edge a specific distance. In climate zones 4 and 5, that distance is 2 feet, and in climate zones 6, 7, and 8 that distance is 4 feet.

Note : For areas prone to termites verify with the local code requirements.

For any further information, please don’t hesitate to contact us.

Thank you,



Randy Nicklas, P.E.
Senior Engineer, Residential

Maxime Duzyk
Director of Building Science and Engineering

3315 E. Division Street, Arlington, TX 76011
Tel: 817.640.4900 888.224.1533
www.huntsmanbuildingsolutions.com

A business unit of Huntsman Corporation

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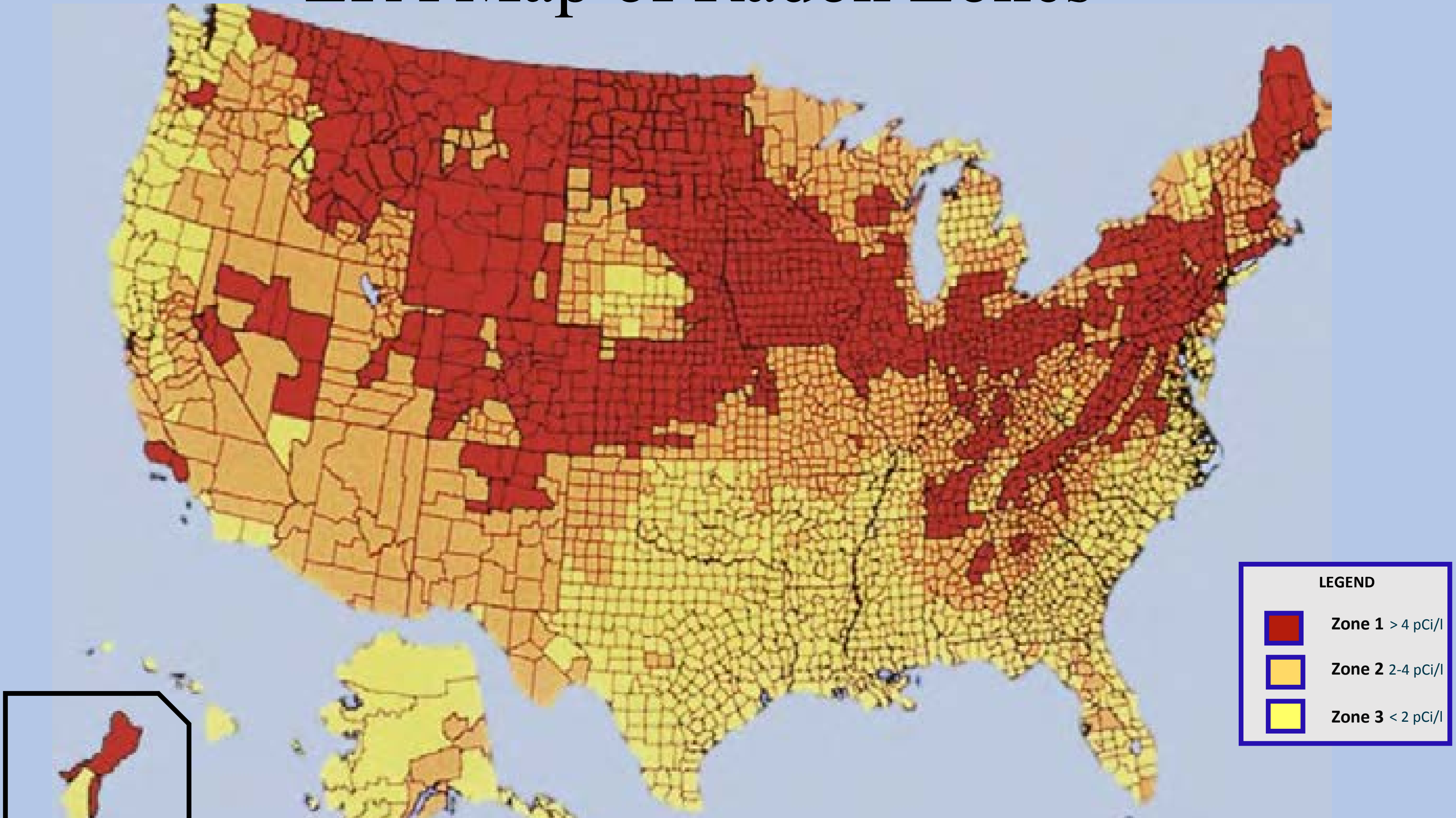
- *FEMA. (December 2010). Home Builder's Guide to Coastal Construction. Technical factsheet series*
- *FEMA P-499 SCHL. (1999). Basement walls that dry quickly. Research Highlights. Technical series 99-109*
- *Test Report No 124031/2018, Radon diffusion coefficient of the polyurethane foam insulation HEATLOK HFO in accordance with K124/02/95 (method C of ISO/DIS 11665-13*
- *Passive Radon Control System for New Construction. (May 1995). United States Environmental Protection Agency*
- *Building Radon Out. A step-by-step Guide on How to Build Radon-Resistant Homes. (April 2001). United States Environmental Protection Agency*
- *2015 International Residential Code, Appendix F.*
- *Demilec, Case Study, Basement Flooding, 2017*
- *Safetech Environmental, Report on the Suitability of Demilec Heatlok™ Soya as a Soil Gas Barrier for Radon, 2017*
- *Building Science Corporation, Insight 101, Rebuilding Houston "Wash and Wear" (November 2017), Joseph W. Lstiburek*
- *Honeywell, Severe Weather and Closed-Cell Spray Foam : A Better Building Technology*
- *NRC-CNRC (November 2000), In-situ Performance Evaluation of Exterior Insulation Basement System `(EIBS) – Spray Polyurethane Foam Summary Report*
- *CNRPP/AARST,* http://aarst-nrpp.com/wp/

EPA Map of Radon Zones



Guam – Preliminary Zone Designation

The Map of Radon Zones was developed in 1993 to identify areas of the U.S. with the potential for elevated indoor radon levels. The map is intended to help governments and other organizations target risk reduction activities and resources. The Map of Radon Zones should not be used to determine if individual homes need to be tested. No matter where you live, test your home for radon—it's easy and inexpensive. Fix your home if your radon level is 4 picocuries per liter (pCi/L) or higher. Consider fixing if your level is between 2 and 4 pCi/L.

The Map of Radon Zones was developed using data on indoor radon measurements, geology, aerial radioactivity, soil parameters, and foundation types. EPA recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential for a specific area.

HEATLOK HFO PRO
RADON CONTROL SOLUTIONS

HEATLOK HFO PRO WAS TESTED IN AN INDEPENDENT LABORATORY AS A RADON CONTROL SYSTEM FOR AN UNDER SLAB APPLICATION. ITS COMPRESSIVE STRENGTH MAKES IT SUITABLE FOR DIRECT APPLICATION UNDER A CONCRETE SLAB WITHOUT DAMAGE OR DETERIORATION.

IN ONE APPLICATION, IT'S POSSIBLE TO INSULATE A COMPLETE BASEMENT FROM THE BASEMENT SLAB UP TO THE RIM JOIST, PROVIDING A TIME AND COST EFFICIENT RADON CONTROL SOLUTION.

THE CONTINUITY OF INSULATION AND PERFECT SEALING OF THE FOAM, WHICH ELIMINATE ALL GAPS AND JUNCTIONS, MAKE HEATLOK HFO PRO AN OPTIMAL RADON BARRIER SYSTEM COMPARED TO RIGID PANELS WITH A CAULKING AND TAPE APPROACH.

HEATLOK HFO PRO PROVIDES UNDER SLAB THERMAL INSULATION, AN AIR BARRIER SYSTEM, A VAPOR BARRIER AS WELL AS A RADON CONTROL SYSTEM.

IT IS GOOD PRACTICE TO APPLY 2" MIN. OF HEATLOK HFO PRO UNDER SLABS WITH HEATED FLOOR SYSTEMS IN COLD CLIMATE ZONES.

HEATLOK HFO PRO'S RADON CONTROL SOLUTION CAN BE USED IN RESIDENTIAL, COMMERCIAL AND INSTITUTIONAL APPLICATIONS, AS WELL AS IN RETROFIT BUILDINGS.

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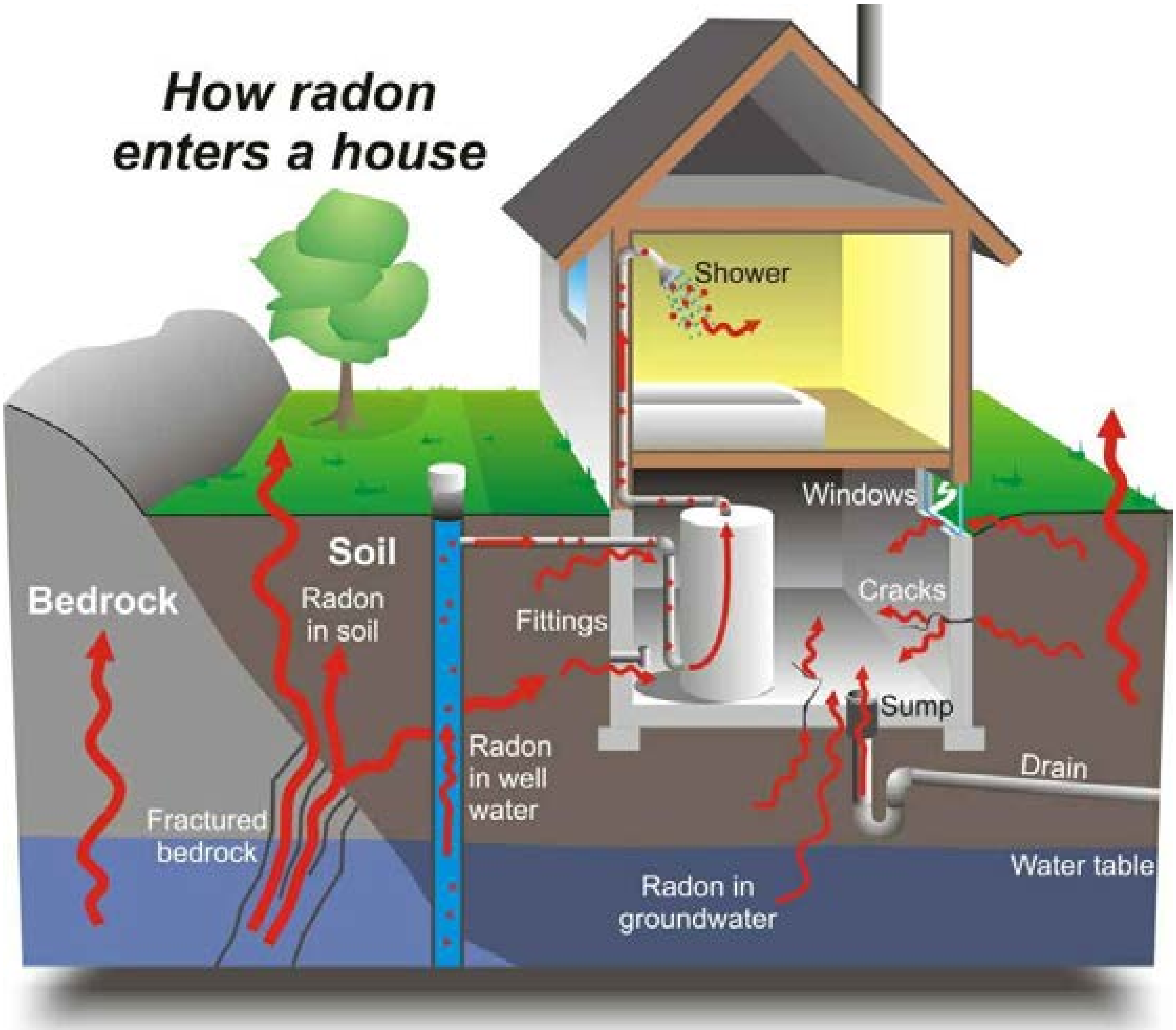

Source: Natural Resources Canada

HEATLOK HFO PRO'S RADON PROTECTION IS ACHIEVED BY 1" MINIMUM ON WALL SURFACE AND 1-1/4" MINIMUM ON LOOSE GRAVEL

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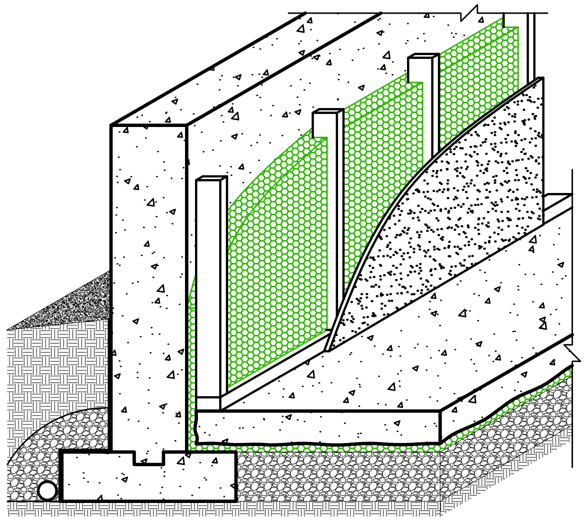
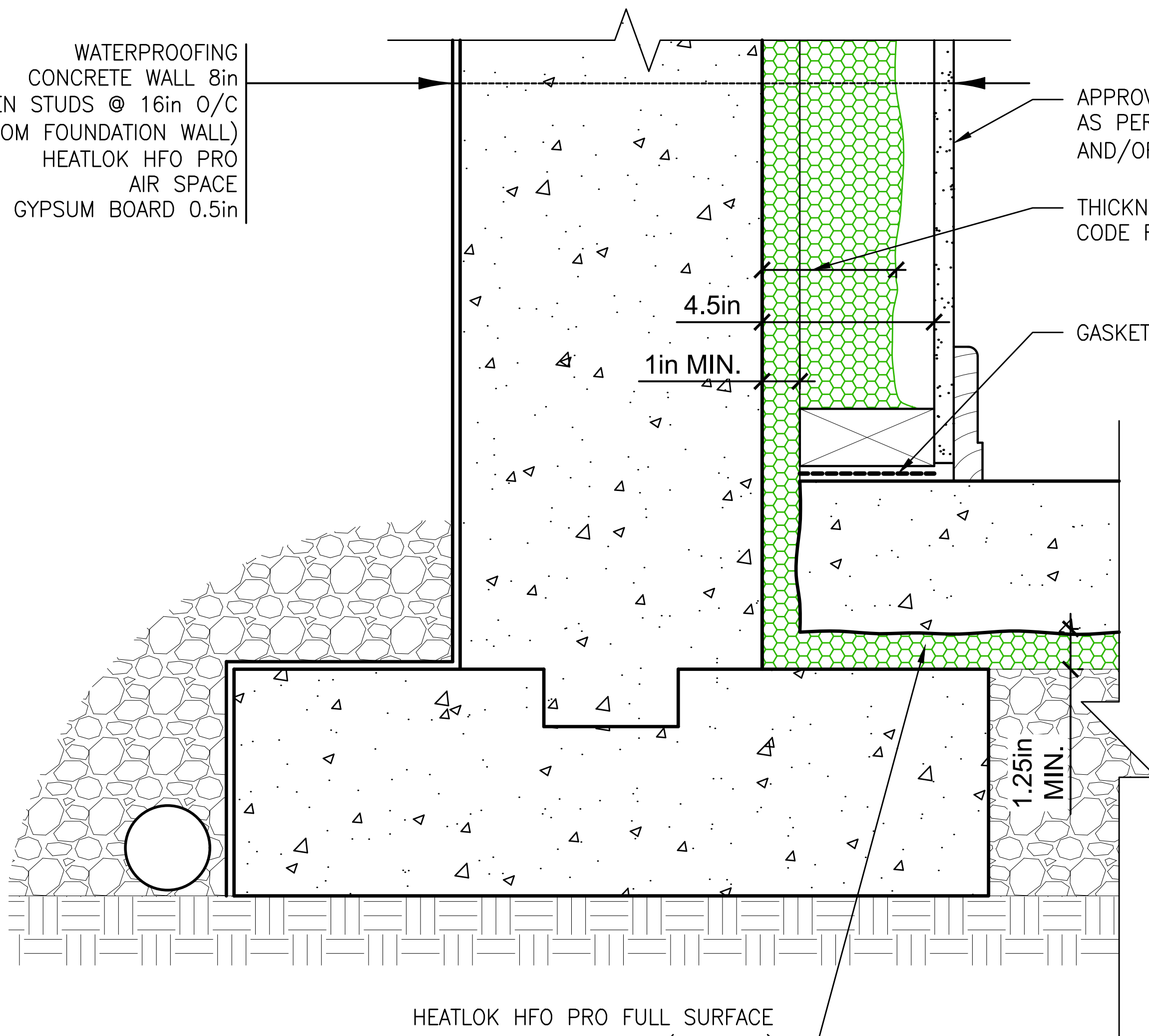
WITH HEATLOK HFO PRO YOU GET:

- RADON CONTROL
- FLOOD–RESISTANT BASEMENT
- THINNER PERIMETER WALL
- WHOLE BASEMENT INSULATION WITH NO JOINTS OR GAPS





TYPICAL DETAIL - WOOD FRAMING - BASEMENT + UNDER SLAB APPLICATION

TOTAL APPLICATION IN 2 VISITS

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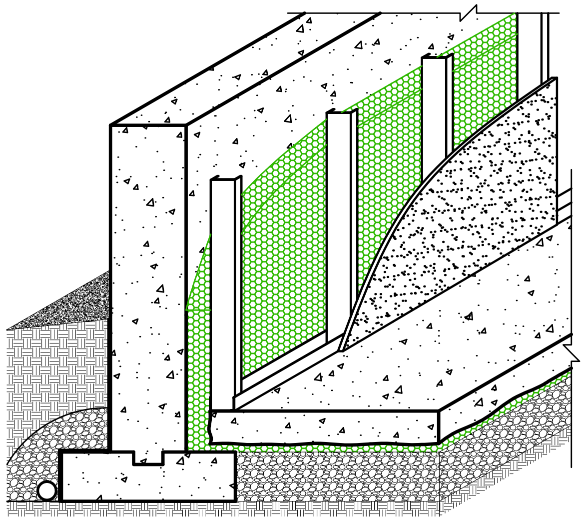

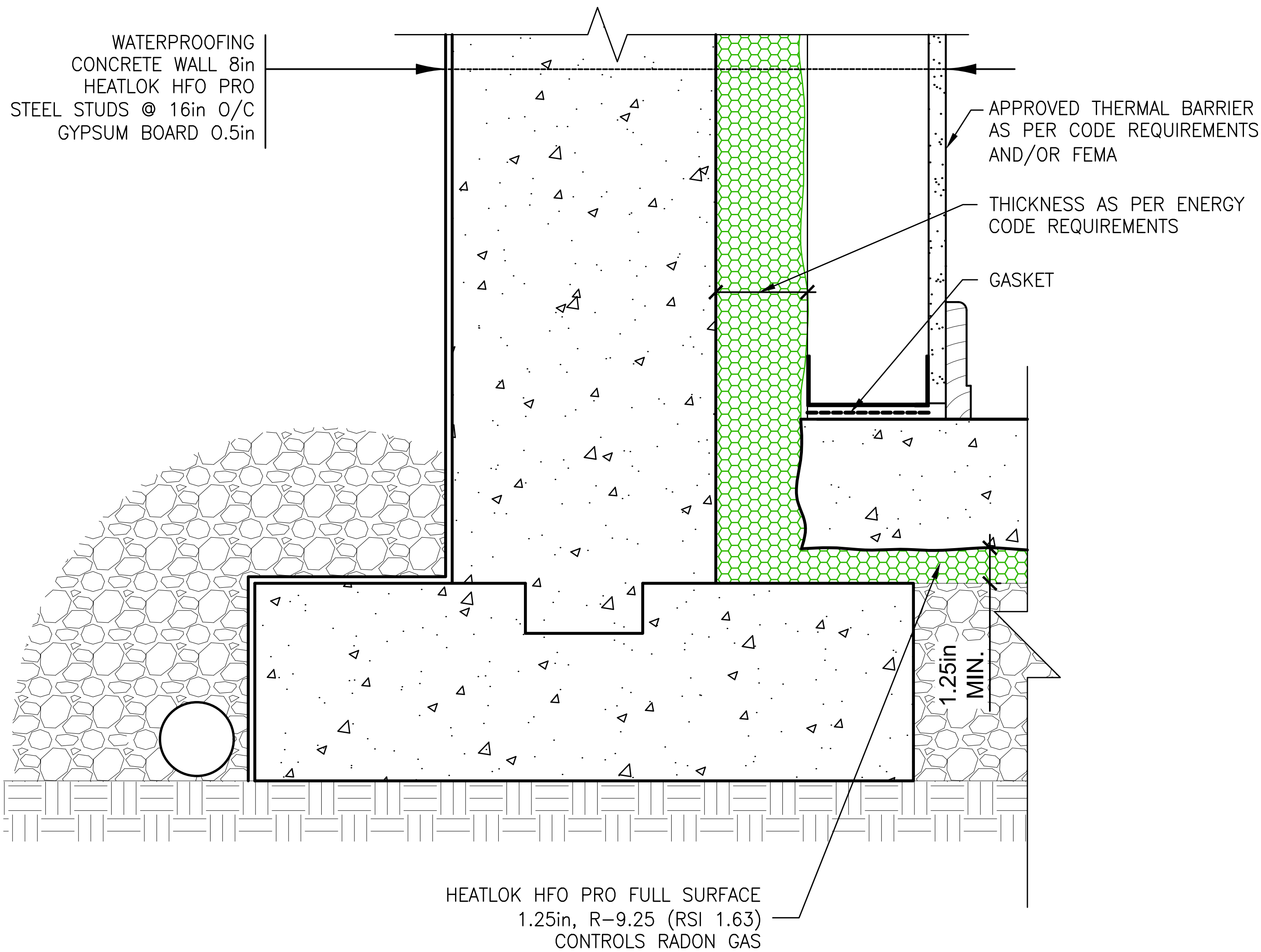

TYPICAL DETAIL - METAL FRAMING - BASEMENT + UNDER SLAB APPLICATION

TOTAL APPLICATION IN 1 VISIT

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WITH HEATLOK HFO PRO YOU GET:

- RADON CONTROL
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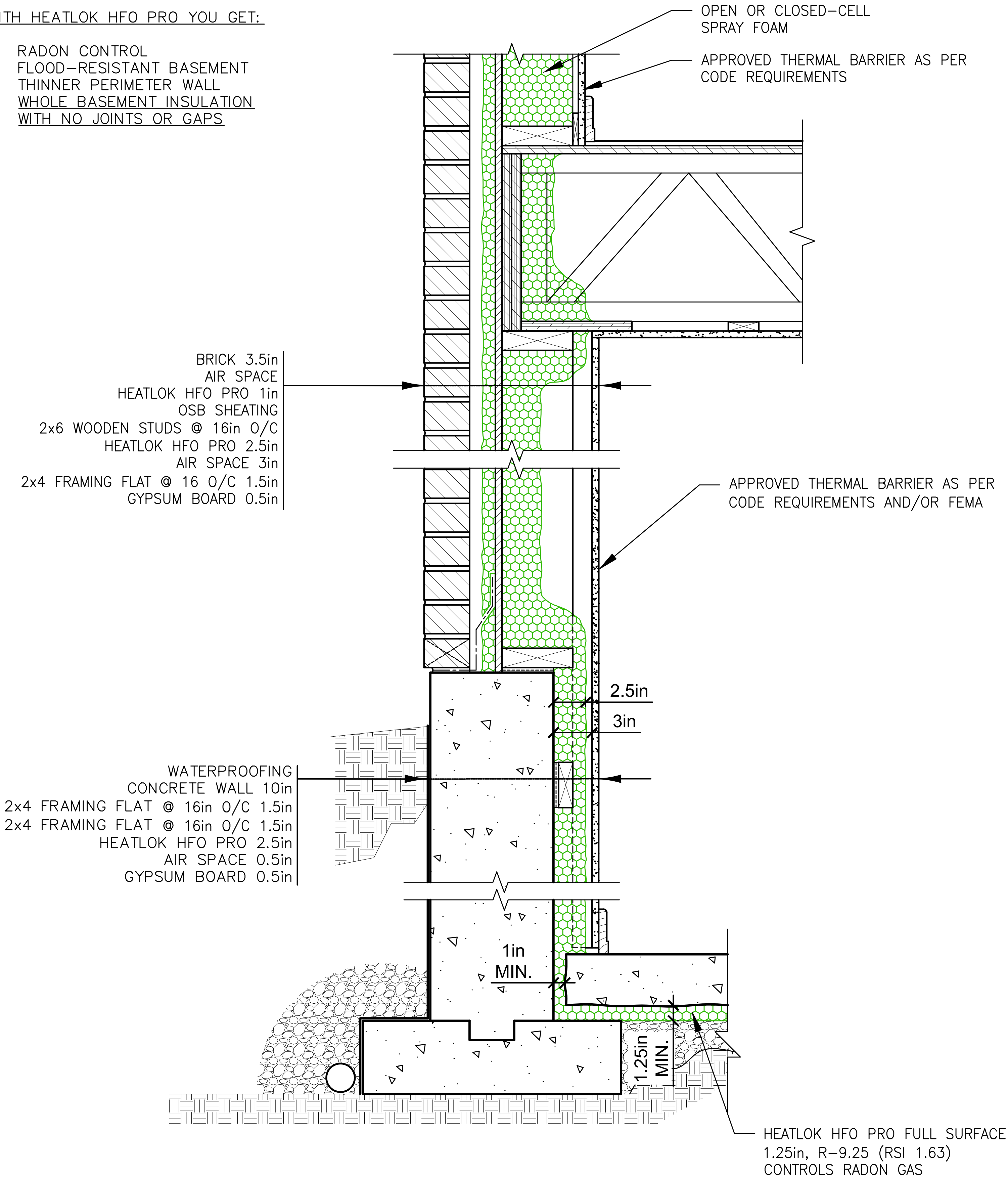
- THINNER PERIMETER WALL
- WHOLE BASEMENT INSULATION WITH NO JOINTS OR GAPS



TYPICAL DETAIL - WOOD FRAMING - BASEMENT + UNDER SLAB APPLICATION

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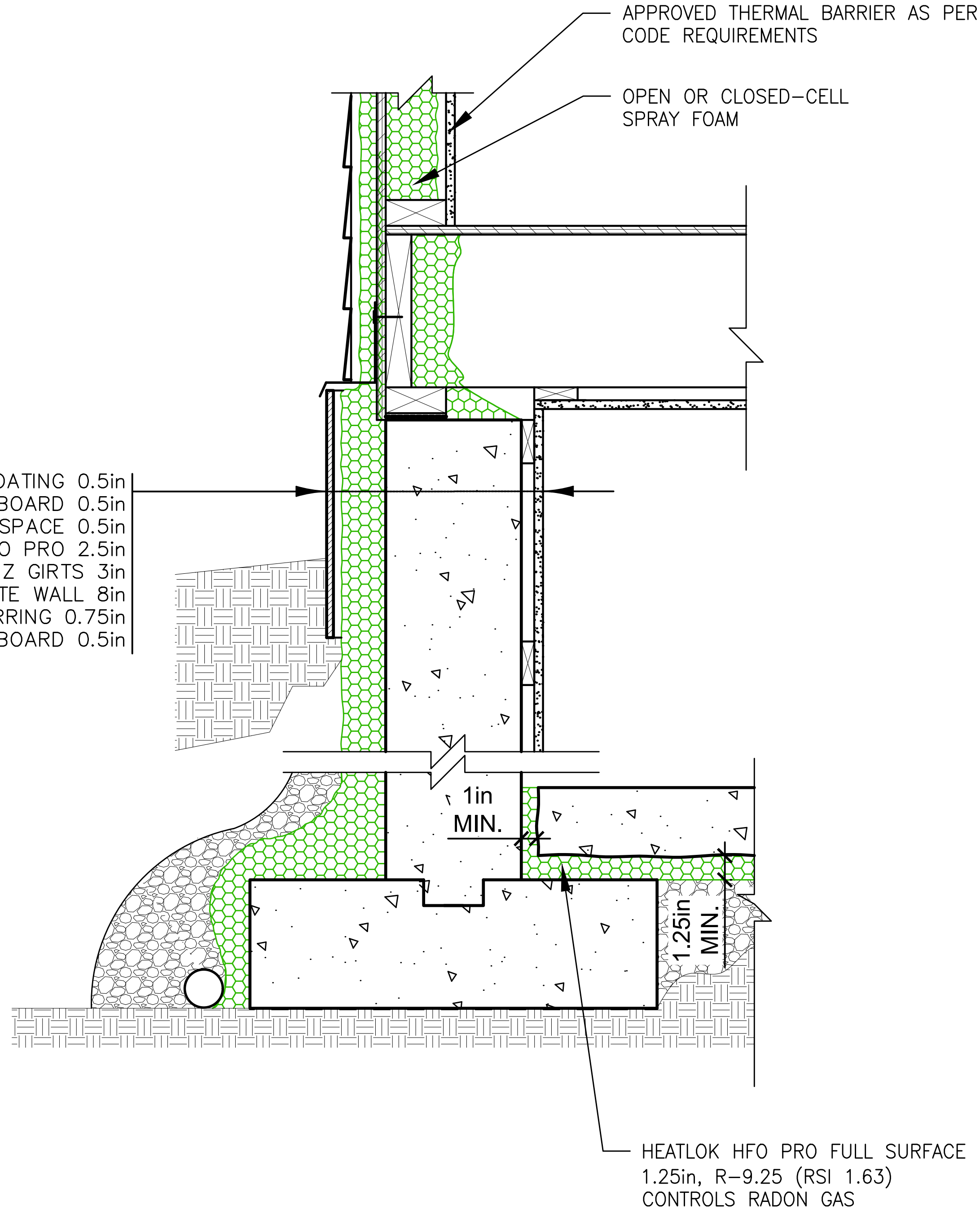
WITH HEATLOK HFO PRO YOU GET:

- RADON CONTROL
- FLOOD–RESISTANT BASEMENT
- THINNER PERIMETER WALL



TYPICAL DETAIL - WOOD FRAMING - BASEMENT + UNDER SLAB APPLICATION

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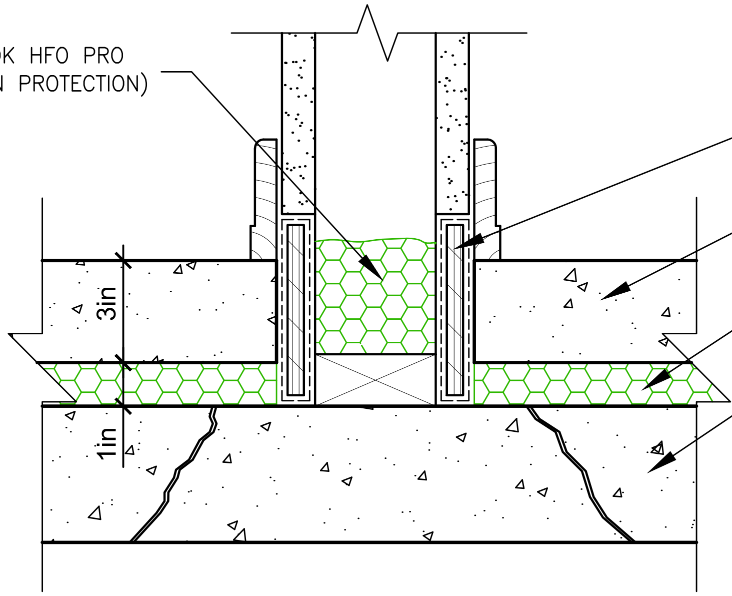

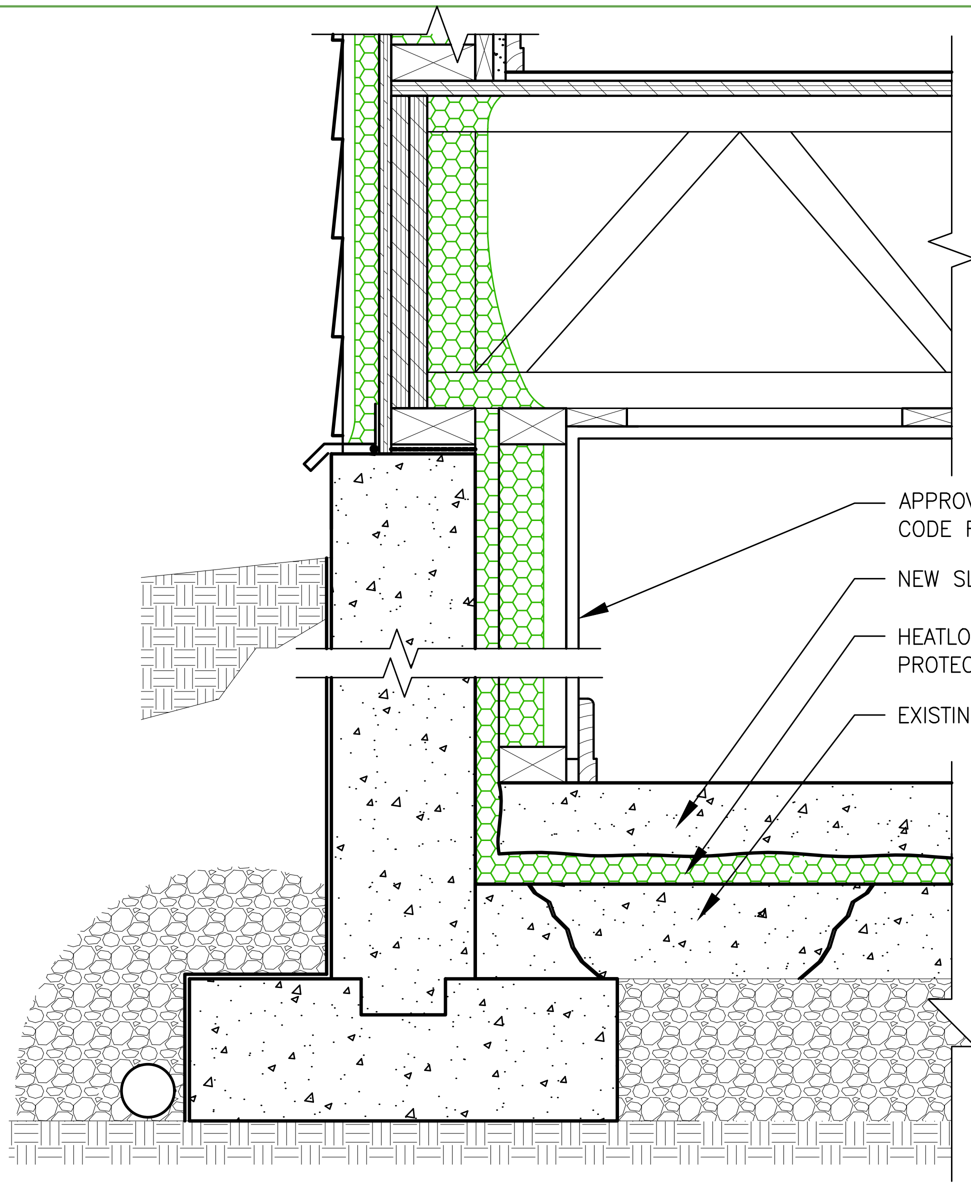

TYPICAL DETAIL - EXISTING SLAB - BASEMENT RETROFIT APPLICATION

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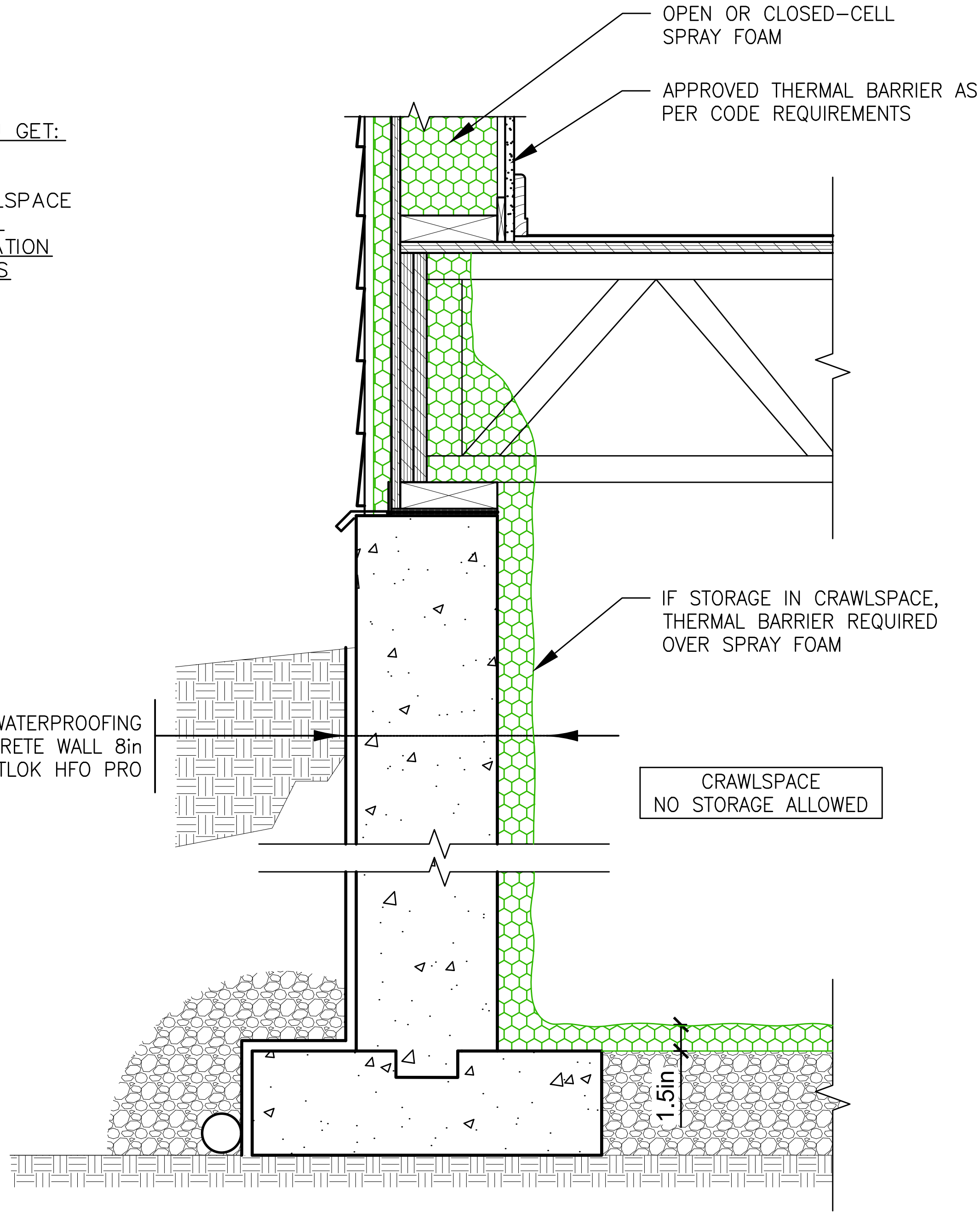
WITH HEATLOK HFO PRO YOU GET:

- RADON CONTROL
- FLOOD-RESISTANT CRAWLSPACE
- THINNER PERIMETER WALL
- WHOLE BASEMENT INSULATION WITH NO JOINTS OR GAPS



TYPICAL DETAIL - UNVENTED CRAWLSPACE APPLICATION

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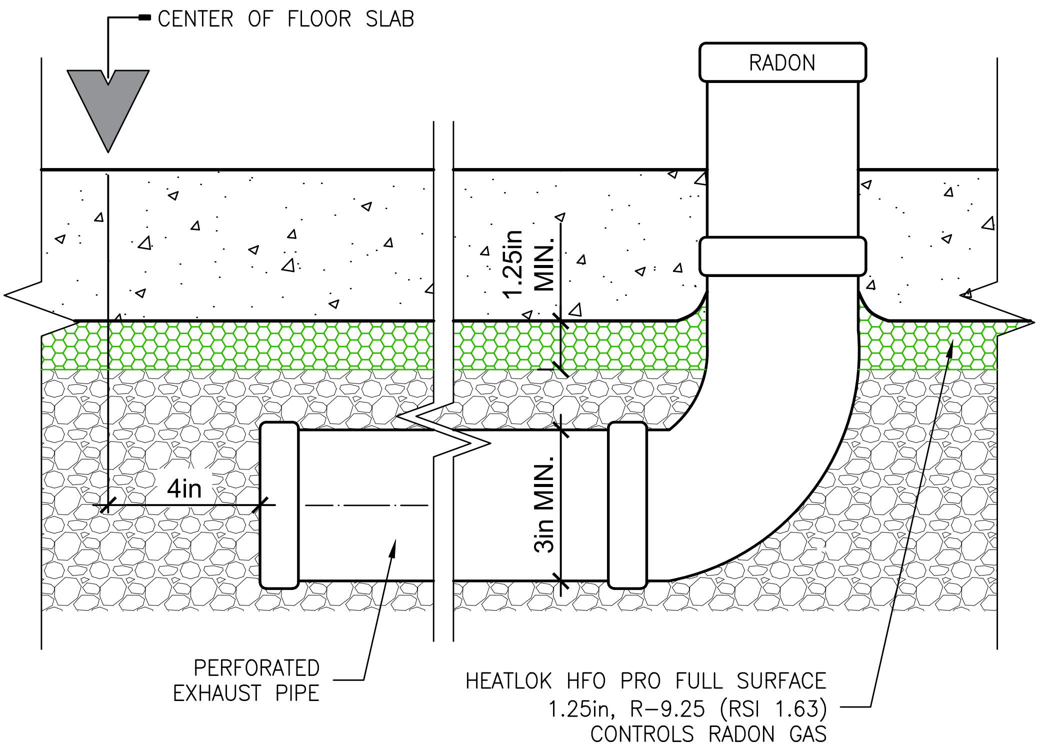
NOTE:

- PIPE SHALL BE INSTALLED IN NEW CONSTRUCTION IN HIGH POTENTIAL LEVEL TERRITORY ACCORDING TO EPA RECOMMENDATIONS
- CONNECT EXHAUST FAN ONLY IF CONCENTRATION IS ABOVE EPA REQUIREMENTS
- PIPE IDENTIFICATION IS MANDATORY
- EXHAUST PIPE CONNECTION SHOULD BE LOCATED IN THE MECHANICAL ROOM



EXHAUST PIPE UNDER SLAB APPLICATION

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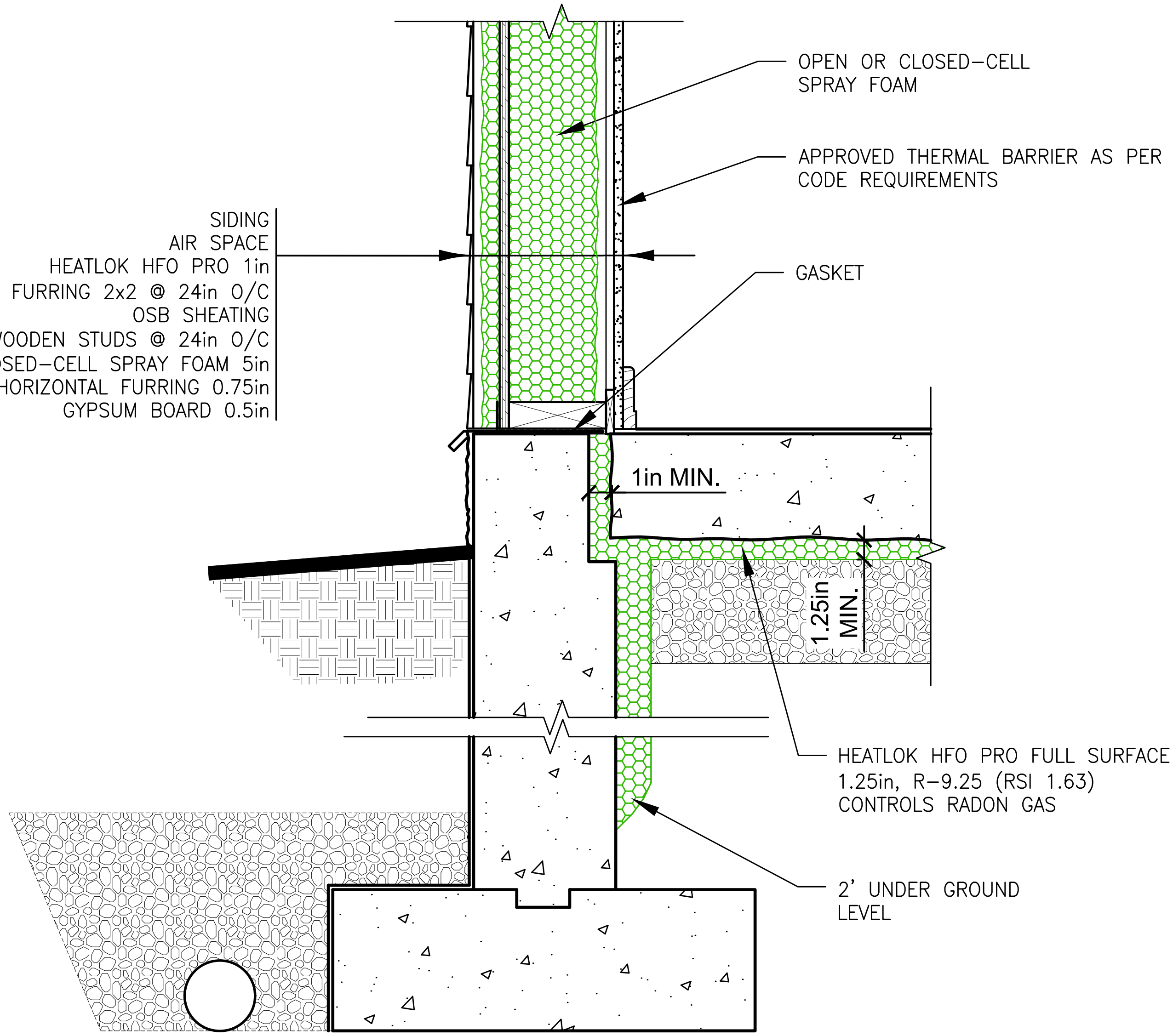

TYPICAL DETAIL - SLAB ON GRADE APPLICATION

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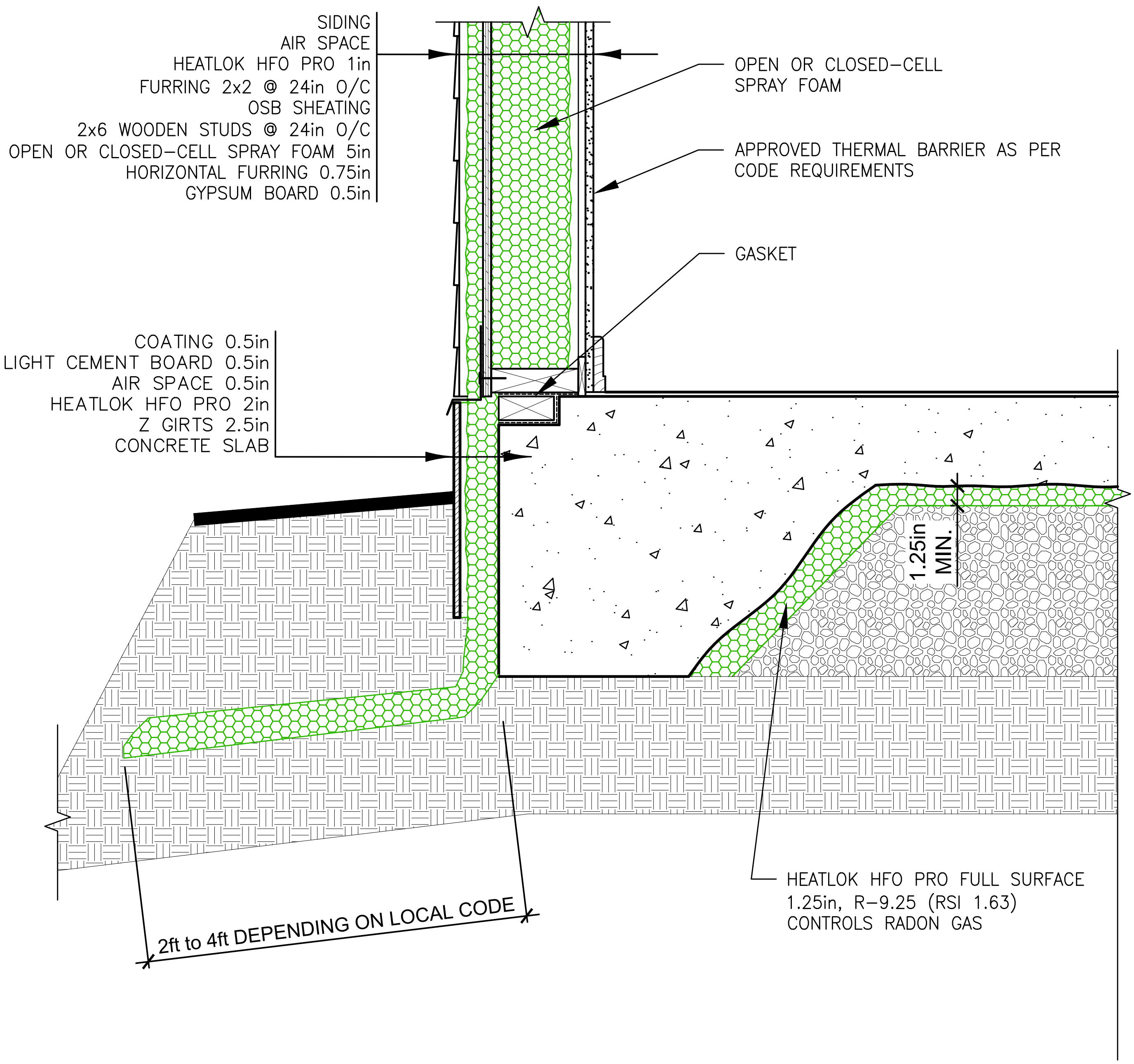

TYPICAL DETAIL - SLAB ON GRADE APPLICATION

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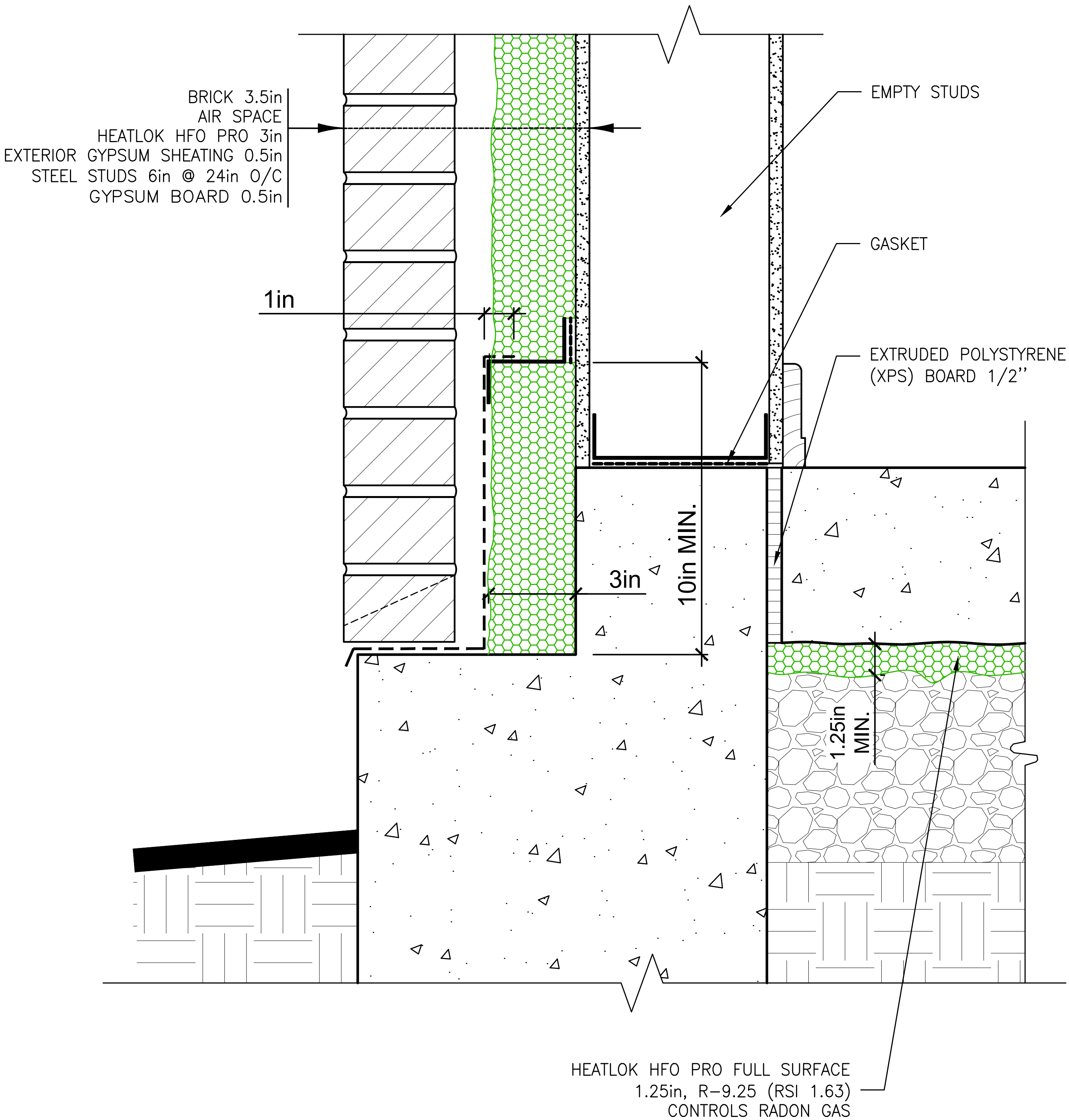

TYPICAL DETAIL - SLAB ON GRADE - COMMERCIAL & INSTITUTIONAL APPLICATION

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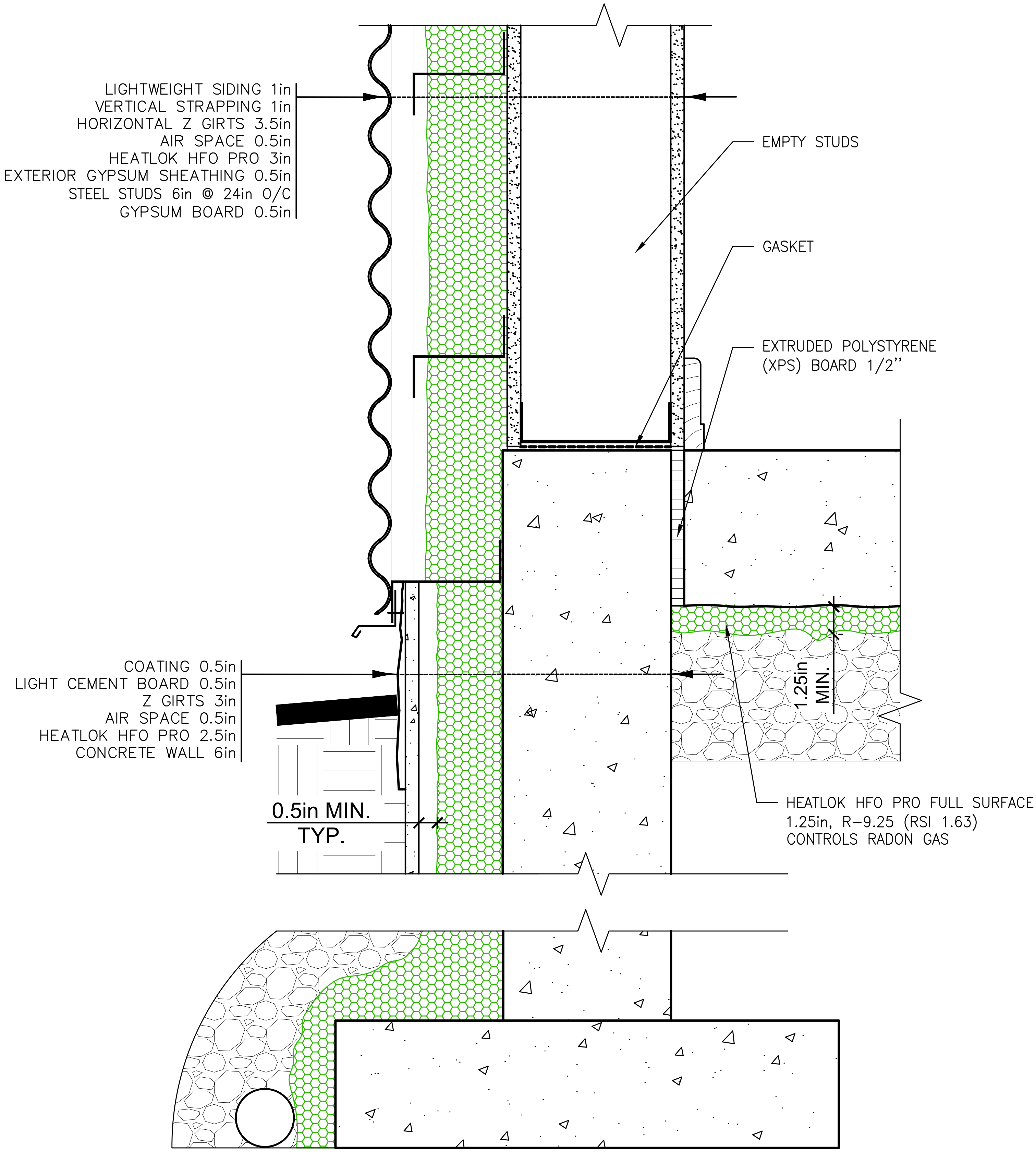

TYPICAL DETAIL - SLAB ON GRADE - COMMERCIAL & INSTITUTIONAL APPLICATION

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HEATLOK® HFO PRO

DEMILEC

TECHNICAL DATA SHEET

Heatlok® HFO Pro is a two component, closed cell, spray applied, rigid polyurethane foam system. This product uses recycled plastic materials, rapidly renewable soy oils, and the blowing agent has zero ozone depleting potential. Heatlok HFO Pro complies with the intent of the International Code Council's residential and commercial building codes and is commonly used as a thermal insulation, air barrier, vapor retarder and water resistive barrier in above grade, below grade, interior and exterior applications.

PHYSICAL PROPERTIES			
ASTM D 1622	Core Density	2.0 – 2.4 lb/ft³	32.0 – 38.4 kg/m³
ASTM C 518	Aged Thermal Resistance	1" = 7.4 ft²h°F/BTU 3.5" = 23 ft²h°F/BTU	1" = 1.3 Km²/W 3.5" = 4.04 Km²/W
ASTM E 283	Air Leakage @ 75 Pa @ 1"	< 0.02 L/sm²	
ASTM E 2178	Air Permeance @ 75 Pa @ 1"	< 0.02 L/sm²	
ASTM E 96	Water Vapor Permeance Class II vapor barrier per IBC Section 202 @ 1"	0.91 perms	52.5 ng/Pa•s•m²
	Class II vapor barrier @ ≤ 1 perm	1"	25.4mm
ASTM D 2842	Water Absorption (volume)	0.3%	
ASTM D 1621	Compressive Strength	31 psi	214 kPa
ASTM D 1623	Tensile Strength	44 psi	303 kPa
ASTM D 2126	Dimensional Stability @ 158°F (70°C) 97% R.H. (168 hours)	-3.7 (% volume change)	
VOC Emissions	UL Environment (Greenguard Gold)	Meets Criteria	
ASTM C 1338	Fungi Resistance	No fungal growth	
ASTM D 2856	Closed Cell Content	98%	
ASTM C 1029	Standard specification for spray applied rigid cellular polyurethane thermal insulation	Type II Compliant	

FIRE TEST RESULTS		
ASTM E 84	Surface Burning Characteristics, 4" thick Flame Spread Index Smoke Developed	Class I 12 350 – 400
AC 377 Appendix X	Ignition Barrier – Compliant with 2009, 2012 & 2015 IBC and IRC, and ICC-ES AC-377 Appendix X, for use in attics and crawl spaces without a prescriptive ignition barrier or intumescent coating.	Pass
NFPA 286	Thermal Barrier – Compliant with the 2009, 2012 & 2015 IBC and IRC, as an interior finish without a 15 minute thermal barrier when coated with DC-315 at 18 mils wet film thickness, 12 mils dry film thickness, or Blazelok™ TBX at 18 mils wet film thickness, 12 mils dry film thickness.	Pass
ASTM D 1929	Ignition Properties (spontaneous ignition temperature)	766°F (408°C)

RECYCLED & RENEWABLE CONTENT	
Recyclable Content	19%
Renewable Content	6%

REACTIVITY PROFILE			
Cream Time	Gel Time	Tack Free Time	End of Rise
0 – 1 seconds	2 seconds	3 – 4 seconds	3 – 4 seconds

HEATLOK® HFO
PRO

LIQUID COMPONENT PROPERTIES*		
PROPERTY	**A-PMDI ISOCYANATE**	**HEATLOK HFO PRO RESIN**
Color	Brown	Blue
Viscosity @ 77°F (25°C)	180 – 220 cps	500 – 800 cps
Specific Gravity	1.24	1.17 – 1.21
Shelf Life of unopened drum properly stored	12 months	6 months
Storage Temperature	50 – 100°F (10 – 38°C)	59 – 77°F (15 – 25°C)
Mixing Ratio (volume)	1:1	1:1

*See SDS for more information.

RECOMMENDED PROCESSING CONDITIONS*		
Initial Primary Heater Setpoint Temperature	105 – 115°F	41 – 46°C
Initial Hose Heat Setpoint Temperature	105 – 115°F	41 – 46°C
Initial Processing Setpoint Pressure	1200 – 1400 psi	8274 – 9653 kPa
Substrate & Ambient Temperature	Summer > 50°F Winter > 15°F	Summer > 10°C Winter > -9°C
Moisture Content of Substrate	≤19%	≤19%
Moisture Content of Concrete	Concrete must be cured, dry and free of dust and form release agents.	

*Foam application temperatures and pressures can vary widely depending on temperature, humidity, elevation, substrate, equipment and other factors. While processing, the applicator must continuously observe the characteristics of the sprayed foam and adjust processing temperatures and pressures to maintain proper cell structure, adhesion, cohesion and general foam quality. It is the sole responsibility of the applicator to process and apply Heatlok HFO Pro within specification.

General Requirements: Equipment must be capable of delivering the proper ratio (1:1 by volume) of polymeric isocyanate (PMDI) and polyol blend at adequate temperatures and spray pressures. Substrate must be at least 5 degrees above dew point, with best processing results when ambient humidity is below 80%. Substrate must also be free of moisture (dew or frost), grease, oil, solvents and other materials that would adversely affect adhesion of the polyurethane foam. Applicators should limit the application of this product to no more than a thickness of 2” (50mm) per pass (after expansion) to avoid fire hazards (including spontaneous combustion) resulting from excessive heat generation. A second 2” (50mm) layer may be applied immediately after the first one has fully risen. Alternatively, a single pass of up to 3” (76mm) may be applied. In either case, if subsequent passes are needed, applicators should wait until the core temperature of the foam has dropped below 100°F to allow any reaction heat to dissipate from the prior applications before attempting to reapply the product.

RECOMMENDED MAXIMUM PASS THICKNESSES		
Maximum Pass	3”	76mm
Dual Pass (x” + x”)	2” + 2”	50mm + 50mm

Heatlok HFO Pro must be separated from the interior of the building by an approved thermal barrier or an approved finish material equivalent to a thermal barrier in accordance with applicable codes. Heatlok HFO Pro must be sprayed at a minimum thickness of 1” per pass. This product must not be used when the continuous service temperature of the substrate or foam is below -60°F (-51°C) or above 180°F (82°C). Heatlok HFO Pro should not be used to cover flexible ductwork.

Disclaimer: The information herein is to assist customers in determining whether our products are suitable for their applications. We request that customers inspect and test our products before use and satisfy themselves as to contents and suitability. Nothing herein shall constitute a warranty, expressed or implied, including any warranty of merchantability or fitness, nor is protection from any law or patent inferred. All patent rights are reserved. The foam product is combustible and must be protected in accordance with applicable codes. Protect from direct flame and spark contact, around hot work for example. The exclusive remedy for all proven claims is replacement of our materials.

MADE IN USA · U.S. GREEN BUILDING COUNCIL MEMBER · ETL LISTED US Intertek · UL GREENGUARD GOLD · IAPMO ES

CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF CIVIL ENGINEERING – TEST LABORATORY
Accredited by ČIA, accreditation No. 1048
Thákurova 7, 166 29 Praha 6
L 1048

COMPARISON OF RADON BARRIER PROPERTIES OF HEATLOK HFO FOAM INSULATION WITH PE MEMBRANE

Radon diffusion coefficient *D* is a material constant that shows the ability of radon to diffuse in the material. The radon diffusion coefficient alone cannot demonstrate the real barrier properties of a particular waterproofing product.

The ability of a material to form an efficient barrier against radon diffusion is expressed by the **radon resistance R_{Rn}** that is defined according to the following equation.

$$R_{Rn} = \frac{\sinh d/l}{\lambda . l} \qquad [s/m]$$

where d is the thickness of the material [m], λ is the radon decay constant [$2,1.10^{-6}$ s^{-1}] and l is the radon diffusion length in the material [m]. Radon resistance must be always stated together with the thickness of the material. Greater value of the radon resistance means better barrier properties.

Comparison of tested materials

Sample	*d* [mm]	*D* [m²/s]	R_{Rn} [s/m]	R_H/R_{PE} [-]
PE (CAN-CGSB-51.34-M)	0,15	$7,2.10^{-12}$	21.10^6	-
Heatlok® HFO	15	$1,3.10^{-10}$	199.10^6	9,5
	20		382.10^6	18,2
	25		725.10^6	34,5
	30		$1\,370.10^6$	65,2
	50		$17\,410.10^6$	829,0

Legend: R_H – radon resistance of Heatlok® HFO foam insulation, R_{PE} – radon resistance of PE

As can be seen from the Table, the barrier properties of Heatlok® HFO foam insulation of specified thicknesses are at least 9,5 times better than those of PE membrane of the thickness of 0,15 mm.

Praha, 11.8.2020 Martin Jiránek

Case Study

Basement Flooding

Situation

On May 22, 2017, following the river flooding in the spring, Demilec visited a flooded basement with 4’ of contaminated water (photo 1). The basement was insulated entirely with Airmetic Soya closed-cell spray foam. The purpose of this visit was to check the condition of the foam insulation after 5 days of immersion. The contaminated water was mixed with sewage and oil spillage.

Solution

Prior to the visit, the surface of all the walls had been washed and the basement had been cleaned with a pressure washer. Dehumidifiers and industrial fans had been in operation for 5 days (photo 2). In order to verify the effects of the flooding on the spray foam insulation, samples were taken on site for laboratory testing. Readings of the moisture content in the wood were made in several places (photo 3).

Even after being submerged for several days, the spray foam insulation was dry and showed no signs of deterioration. Water absorption and mold growth were not an issue. The uncovered wood dried with the help of dehumidifiers and fans. However, the portion of the wood studs embedded in the polyurethane were still moist.

Conclusion

The existing spray foam insulation may remain in place, but the drying of the wood must be facilitated with industrial equipment. It is important to thoroughly clean the joints between the wood structure and the floor to allow the wood to dry out as quickly as possible. The wood must reach a moisture content of less than 19% in order to allow the installation of finishing panels, as required by the building code (Article 9.3.2.5.).

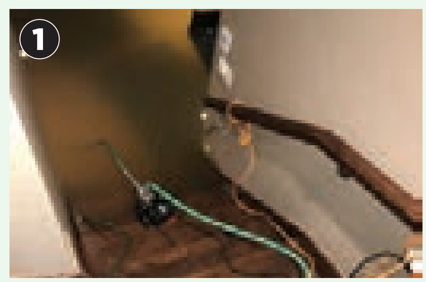
Date:
May 29, 2017

Location:
Montreal, Quebec, Canada

Construction Type:
Residential

Exterior plaster, 8” of concrete, 2.5” of Airmetic Soya, 2”x4” wood studs spaced 1” from the foundation wall, air space, 0.5” gypsum.

Product:
Airmetic Soya
Closed Cell Spray Foam Insulation



For more information, contact the Demilec Building Science Department at 817-640-4900.
www.Demilec.com

REPORT ON THE SUITABILITY OF DEMILEC HEATLOK™ SOYA AS A SOIL GAS BARRIER FOR RADON

Prepared for:

Demilec Heatlok Soya

870 Cure Boivin
Boisbriand, Quebec
J7G 2A7

Project: 2-012016
February 8th, 2017

52 McIntyre Place, Unit J
Kitchener, ON
N2R 1H9

TEL 519.954.2732 1.877.GO.TO.SEL
FAX 519.772.1968
www.safetechenv.com

REPORT ON THE SUITABILITY OF DEMILEC HEATLOK™ SOYA AS A SOIL GAS BARRIER FOR RADON

1.0 BACKGROUND

Current national and provincial building codes of Canada contain provisions to control the ingress of ground sourced radon (*soil gas*) into buildings to protect building occupants from an increased risk of radon induced lung cancer. "Radon overexposure is the leading cause of lung cancer in non-smokers and it's estimated that in Canada there are more than 3300 lung cancer deaths related to radon each year." (Canadian Cancer Society, 2016). Contrary to previous conventional thinking, the distribution of radon prone soils is not isolated to a few geographic areas, and virtually all indoor building environments will contain radon to some degree. In March 2012, Health Canada completed a cross-county survey of radon concentrations in nearly 14,000 homes. "The results from this two-year study concluded that 6.9% of Canadians are living in homes with radon levels above the current radon "actionable level" of 200 Becquerels per cubic metre of air (Bq/m^3)" (Canadian Nuclear Safety Commission, 2012). The only way to determine the radon levels are in a building is to test it after construction under normal occupied conditions. There is currently no reliable or affordable method to determine if a building will or won't have high radon levels prior to its construction; justifying the code requirements to control the ingress of radon for all buildings.

Soil gas ingress is managed in new construction and renovations by: i) applying soil gas barriers to ground contact floors, foundation walls and roofs, ii) providing a gas collection layer (e.g. clear stone or gas mat) under all ground contact floors, iii) installing a piping system for the extraction of soil gas from under the floors, iv) sealing seams, cracks, penetrations and all openings in ground contact floors, walls and roofs; and iv) testing the radon levels in the building after construction. In the event that the indoor radon concentrations exceed the Health Canada action level the piping system can be connected to an extraction fan to control radon entry and exhaust the accumulated radon safely outdoors.

Some building codes do not currently mandate indoor radon testing after construction. "There is an entrenched belief that simply extending the continuity of the air barrier through the building foundation, as prescribed by the national and some provincial building codes, is sufficient by itself to control indoor radon levels. These views are contrary to the findings of Health Canada and extensive evidence and experience from relevant agencies in the United States and Europe." (Decker et. al., 2014). Obtaining a perfect air barrier/soil gas barrier is virtually imposibe using conventional construction methods (e.g. sheeting and taping). Spray-applied soil gas barriers (i.e. Demilec Heatlok™ Soya) dramatically increase the efficacy of soil gas control systems due to the high level of air tightness provided. In addition, at 12 millimeter (mm) thickness, Demilec Heatlok™ Soya provides four (4) times more resistance to radon diffusion than 6-mil polyethylene sheeting and where applied, eliminates the requirement for manual caulking of seams, cracks, penetrations and saw cuts in ground contact walls, floors and roofs.

Ground sourced radon enters buildings through leakage and diffusion mechanisms. Soil gas leakage occurs through all openings, cracks, seams and penetrations in ground contact walls, floors and roofs and is driven primarily by stack-effect induced pressure differentials across the building envelope. Mechanical ventilation systems and occupant activity also affect pressure differentials across the building envelope and therefore affect the rate of radon ingress. The pressure differentials required to draw radon into a building are as low as 0.025 Pascal (Pa) or 0.0001 inches of water column (w.c.) which are much lower than the typical pressure differentials imposed on a building. "It has been known for some time that convective flow (leakage) is the main driving force behind elevated radon levels in homes and buildings due to the reduction of pressure relative to the surrounding soil. Diffusion is usually considered the second major driving force and can sometimes result in high indoor radon concentrations. Therefore, barriers that can retard both mechanisms will increase the resistance of the building against radon penetration" (W. Z. Daoud, 1999)

National and some provincial building codes of Canada prescribe the use of polyethylene sheeting soil gas barrier under the slab. "While vapour permeance characteristics of these membranes are well known and specified in Canadian standards, their radon diffusion coefficients are not" (Chen, 2009). This report compares the radon diffusion coefficients of Demilec Heatlok™ Soya with polyethylene sheeting and other commonly used soil gas barriers to demonstrate its suitability as a radon barrier.

2.0 BUILDING CODE REQUIREMENTS

The National Building Code of Canada, as well as provincial building codes of British Columbia, Ontario and Quebec, stipulate radon control in Part 9 (residential construction). In general, these codes describe the use of bituminous dampproofing on foundation exteriors and the use of 0.15 millimeter (mm) polyethylene sheeting under floor slabs as radon gas barriers. The selection criteria for these materials may be related to their known performance as air or vapour barriers. Polyethylene sheeting is often used in building assemblies as an air barrier and or a vapour barrier. Canadian building code requires vapour barrier materials have a permeance of not greater than 60 ng/(Pa·s·m^2) defined by the ASTM E 96/E 96M "Water Vapour Transmission of Materials" using desiccant (dry cup) method; and air barrier materials have an air leakage characteristic less than 0.1 L/(s·m^2) at 75 Pa, or in the case of Ontario not greater than 0.02 L/(s·m^2) at 75 Pa and conform to the CAN/ULC-S741, "Air Barrier Materials – Specification". Polyethylene film at a thickness of 0.15 mm has a dry cup permeance of 3 ng/(Pa·s·m^2) (NRC-CNRC, 1995) and has no measureable air leakage (CMHC SCHL, 1999) making it a sutiable material for such application.

No performance criterion for the maximum permissible rate of radon diffusion through a radon barrier has been established in Canadian building code. This is likely due to a focus on controlling the primary mechanism of radon entry (soil gas leakage) instead of diffusion. "Often used as a vapour barrier polyethelyene is inexpensive to buy. However, it fails or barely meets most air barrier requirements other than air impermeability. It is difficult and relatively expensive to achieve continuity, especially since it is pierced by services and enclosure penetrations" as well as foot traffic during construction (Straube, 2007). Angular gravel can cause significant damage to polyethylene sheeting and rigid board insulation barriers.

Establishing an acceptable radon leakage performance criterion for radon barriers is as straightforward as selecting a building material with low air leakage rates; establishing an acceptable radon permeance rate is more difficult. "The effectiveness of a membrane for reducing the movement of radon into a building is dependent upon the material composition, material thickness, and sealing of the membrane seals" (Kitto, 2016); "of course none of the materials can stop radon flow if they are not properly (i.e. in a gas-tight way) installed" (Walczak, 2015).

3.0 RADON DIFFUSION COEFFICIENTS OF BARRIER MATERIALS

Radon diffusion coefficients are expressed as the amount of radon penetrating a one (1) meter thick material over an area of one (1) square meter per unit time during a radon concentration gradient of 1 or more Bq/m^3 and pressure gradient of zero.

It is not prudent to assume that if a material can adequately resist water vapour diffusion that it can adequately resist radon diffusion as the radon atom is approximately twice the size of a water molecule. Although governed by Ficks Law, radon diffusion is more dynamic than water diffusion as the nuclear decay of radon gas (3.8 day half-life) changes the element over time. Radon diffusion is determined by measuring the flux of a material placed between two chambers with one chamber containing a radon source typically 40 to 50 thousand Becquerels per cubic metre of air (MBq/m^3). The radon diffuses through the sample and radon concentrations on in both chambers (both sides of the material) are measured continuously. When a steady state radon concentration profile exists within the material, the upper chamber is flushed and the increase in radon concentration in the upper chamber is measured. "The radon diffusion coefficient of a material is then determined based on the time-dependent curve of the radon concentration increase in the upper chamber by solving the one-dimensional diffusion equation:" (Chen, 2009)

$$\frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right) - \lambda \mathrm{x} C = \frac{\partial C}{\partial t}$$

where *D* is the radon diffusion coefficient ($m^2\ s^{-1}$), λ the radon decay constant (2.1×10^{-6} s^{-1}), *C* the radon concentration within the material ($Bq\ m^{-3}$) and *t* the time (s).

Radon diffusion coefficients of common vapour barrier membranes used in the Canadian building construction industry were determined in a study conducted by Chen et. al (Chen, 2009). A total of six (6) polyethylene sheet materials of 0.15 mm thickness were tested at the Faculty of Civil Engineering, Czech Technical University in accordance with the K124/02/95 method accredited by the Czech Accreditation Institute. This study reported radon diffusion coefficients from $9.4x10^{-12}$ to $2.1x10^{-11}$ m^2/s with an average of $1.4x10^{-11}$ m^2/s which is consistent with the average radon diffusion coefficients of 0.15 mm polyethylene of $1.6x10^{-11}$ m^2/s reported in a study by W.Z. Daoud and K. J. Renken. (W. Z. Daoud, 1999). "Measurements conducted on over 120 radon-proof materials varied widely from 10^{-15} to 10^{-8} m^2/s. The diffusion coefficients for most radon-proof materials ranged from 10^{-12} m^2/s to 10^{-10} m^2/s. Vapour barrier materials used in Canadian building construction showed radon diffusion coefficients in the range of $5x10^{-12}$ to $2x10^{-11}$ m^2/s, which are comparable with the most commonly used European radon-proof materials." (Chen, 2009). Based on the results Chen et. al. concluded that "all of the tested membranes (0.15 mm polyethylene) can serve as a barrier against soil gas radon" (Chen, 2009).

The ideal radon gas barrier would have: excellent resistant to air/soil gas leakage, excellent adhesion to building elements to maintain seals, durability during the process construction and the life of the building, continuity, low radon permeance (diffusion coefficient) and be immune to the installation deficiencies (e.g. inadequate or improper taping and sealing).

4.0 SUITABILITY OF DEMILEC HEATLOK™ SOYA AS A SOIL GAS BARRIER FOR RADON

Demilec Heatlok™ Soya is a closed-cell (<10% open cells) foam insulation with a density of 33.6 to 36.8 kilograms per cubic meter (kg/m^3), 2.1 to 2.3 pounds per cubic foot (lb/ft^3). It has a water vapour permeance of 37 $ng/(Pa{\cdot}s{\cdot}m^2)$ at 50mm thickness and an air leakage rate of 0.00004 $L/(s{\cdot}m^2)$ at 75 Pa at 25 to 30 mm thickness. These properties conform to the National Building Code of Canada, as well as the provincial building codes of British Columbia, Ontario and Quebec making Demilec Heatlok™ Soya an air barrier at 25 mm and vapour barrier at 32 mm.

To determine radon barrier suitability, Demilec Heatlok™ Soya was laboratory tested at the Faculty of Civil Engineering, Czech Technical University in accordance with the K124/02/95 method accredited by the Czech Accreditation Institute to determine its radon diffusion coefficient. Demilec Heatlok™ Soya was reported to have a radon diffusion coefficient of $1.4x10^{-10}$ m^2/s which falls within the radon diffusion coefficients for most radon-proof materials (10^{-12} m^2/s to 10^{-10} m^2/s) identified by Chen et. al.

"It is well known that the lower the radon diffusion coefficient, the better are the barrier properties against radon penetration through the membrane" (Chen, 2009). As with all diffusion rates the material thickness must always be taken into consideration when determining the permeability of the subject matter (i.e. radon) through the material. As material (i.e. barrier) thickness increases, radon diffusion decreases resulting in a more effective resistance to radon transport by diffusion. The radon resistance of a material is defined by the equation:

$$R_{Rn} = \frac{d}{D}$$

where D is the radon diffusion coefficient ($m^2\ s^{-1}$), d is the thickness of the material (m).

The range of radon diffusion coefficients for 0.15mm polyethylene reported by Chen et. al. at 9.4×10^{-12} to 2.1×10^{-11} m^2/s provide radon resistance between 7.5×10^6 and 16.3×10^6 (s/m) respectively. At typical application thicknesses (38 mm [1.5 inches] for unheated slabs and 50 mm [2 inches] for heated slabs) Demilec Heatlok™ Soya provides a radon resistance of 272×10^6 to 357×10^6 (s/m) respectively which is approximately 17 to 47 times more resistant to radon diffusion than 0.15 mm polyethelyene.

Based on the above Demilec Heatlok™ Soya outperforms 0.15 mm polyethelyene as a diffusive radon barrier. An additional advantage is that "the application of 50 mm (2 inches) closed-cell spray foam over granular as under-slab insulation will attain a continuous air barrier. The spray foam is very likely to survive the pouring of the concrete intact (unlike 0.15mm polyethylene) and will outperform manual sealing measures increasing the efficacy of the gas barrier." (Decker et. al., 2014) The same would hold true for the application of Demilec Heatlok™ Soya as a radon barrier over ground contact walls and roofs.

5.0 CONCLUSIONS

Careful review of the above information demonstrates Demilec Heatlok™ Soya alone is an adequate radon barrier at far less than typical application thicknesses of 38 to 50 mm and can outperform conventional 0.15 mm polyethylene installations by controlling radon diffusion and leakage transport mechanisms. Applying additional radon barrier materials with Demilec Heatlok™ Soya would be unnecessary.

Considering the majority of soil gas intrusion is through air leakage (i.e. through joints, cracks, and penetrations) it is essential to ensure good sealing of joints, cracks, and penetrations and good continuity of the soil gas barrier. Through its ability to expand into crevasses and adhere to building elements, properly applied Demilec Heatlok™ Soya will provide a continuous soil gas barrier, both under-slab and on foundation walls and roofs. Properly applied Demilec Heatlok™ Soya can reduce construction deficiencies inherent to taped or caulked radon barrier system assemblies.

Considerable cost savings may also be realized by using Demilec Heatlok™ Soya as "the cost of sealing (radon) entry routes is highly variable. It can range from a few hundred dollars to $2,000 or more. Although the material cost (caulking and polyethylene used in conventional construction) is relatively low, it is very labour-intensive to do a comprehensive job. As the (building) ages and settles, the seals can deteriorate, and new cracks or entry routes can appear. As a result, there will be an ongoing cost to maintain the seals or an increase in indoor radon levels" (Health Canada, 2013). Kitto and Perazzo "emphasized the importance of selecting a high-performance radon barrier, and sealing of the seams and holes that may occur during placement of the barrier at a building site." (Kitto, 2016). Using Demilec Heatlok™ Soya as a radon barrier can deliver excellent control over radon ingress, provide a high degree of certainty of project success, alleviate labour costs, and decrease future liabilities.

Safetech Environmental Limited

Bruce Decker, C.E.T., ROHT, BSSO
CNRPP Certified:

- Radon Measurement Professional- #CRT 201017
- Radon Mitigation Professional- #CRMT 201624
- Radon CRNCH-INSTALLER Professional- #CRNCH 201625

Senior Project Manager/Technical Advisor

Philip Warren, P. Eng.(QP), PMP
Manager, Environmental Services

6.0 LIMITATIONS

The research, information and conclusions detailed in this report were carried out by trained professional and technical staff in accordance with generally accepted engineering, environmental, industrial hygiene and building science practice. Recommendations made in this report have been made in the context of existing industry accepted guidelines, which were in place at the date of this report and as they relate to the use of Demilec Heatlok™ Soya as a radon barrier only. It is the responsibility of the designer, engineer, architect, builder, contractor, owner etc. to ensure the use of Demilec Heatlok™ Soya is in compliance with all current and applicable acts, regulations, codes, standards, guidelines, by-laws and industry best practice governing the work.

In preparing this report, Safetech Environmental Limited (SEL) relied on information supplied by others. Except as expressly set-out in this report, SEL has not made any independent verification of such information.

Conclusions are based on the information, documents, and specifications made available at the time of this assignment. If any information becomes available that differs from the findings in this report, we request that we be notified immediately to reassess the conclusions provided herein. SEL makes no warranty in regards to the longevity of the spray-on material in keeping it's specified properties over time.

This report has been prepared for the sole use of the person or entity to who it is addressed. No other person or entity is entitled to use or rely upon this report without the express written consent of Safetech Environmental Limited and the person or entity to who it is addressed. Any use that a third party makes of this report, or any reliance based on conclusions and recommendations made, are the responsibility of such third parties. SEL accepts no responsibility for damages suffered by third parties as a result of any designs, decisions or actions based on this report.

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