EnergyIdeas Clearinghouse

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Product & Technology Review

Ultra Concrete Barrier rFOIL™

A single layer of highly reflective aluminum foil sandwiched between two layers of polyethylene bubbles for use as a radiant barrier for concrete slab foundations.

Image provided by Covertech Fabricating, Inc.

Product
Ultra Concrete Barrier rFOIL (Ultra CBF rFOIL)

Manufacturer
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Residential customers can purchase Ultra CBF rFOIL through many local plumbing suppliers specializing in hydronic heating systems. Ultra CBF rFOIL is available to Pacific Northwest contractors from:

- Mechanical Agents, Inc., (206) 464-1925 and (509) 483-0544
- System Components, (405) 557-7968
- Ferguson Enterprises, *www.ferguson.com*

Product History
Ultra Concrete Barrier rFOIL was first manufactured in 1997 for the City of Calgary, Alberta, for use under city sidewalks to prevent freeze-thaw damage. Soon after, TVM began selling Ultra CBF rFOIL for use under radiant-heated slabs.

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Product Function and Application

According to the manufacturer, Ultra CBF rFOIL is a reflective insulation and vapor barrier. It comes in 125-foot-long rolls in widths of 16 inches and 48 inches. The product may be applied as "replacement or complement to rigid insulation" in the following locations:

- Exterior perimeter of concrete foundation walls
- Under concrete slab foundations
- Over concrete slab foundations (under the wood subfloor)
- With radiant heating systems – under concrete pours, or over wood subfloors
- Under carpet

Energy Savings Claims

This information was provided by the manufacturer and is not evaluated in this section.

On their website, the manufacturer claims that Ultra CBF rFOIL "reduces heat loss by 77%", "reduces heat loss" and "saves energy costs" (*www.covertechfab.com/pdf/r107.pdf*, *www.covertechfab.com/pdf/h101.pdf* and *www.covertechfab.com/pdf/rfoil_cbf.pdf*). (See discussion under "*Additional Reviewer Comments*" regarding the "77%" claim).

Non-Energy Benefits

The manufacturer claims that Ultra CBF rFOIL acts as a vapor, methane, and radon barrier. Under-slab vapor retarders and barriers help prevent damage to moisture sensitive floor coverings (such as carpets, tile, wood and polymeric flooring), and to water-sensitive equipment placed on the floor. Vapor retarders may also reduce indoor humidity levels, improving indoor air quality in most climates. In addition, the manufacturer claims that Ultra CBF rFOIL results in "noticeably warmer floors" and "faster response time from radiant heating," improving comfort.

Independent Testing Results

All test results and studies discussed below were commissioned by TVM Building Products and the information was provided by them. Results of some of these studies are presented on their website. For each study, we add comments following a description of the study. To help readers better understand this information, a fact sheet on heat transfer building products is available at: *www.energyideas.org/documents/factsheets/PTR/HeatTransfer.pdf*.

In compression testing performed by Intertek Testing Services, the pressure on Ultra CBF rFOIL samples was gradually brought to maximum pressures ranging from 90 psi to 140 psi – much higher than pressures under a slab. At these high pressures, the thickness of the samples was reduced by 85% to 90% of their original thickness. No bursting of the bubbles occurred and the samples recovered most of their thickness after compression was released. At more typical pressures under a slab (approximately 0.5 psi), the reduction in thickness was negligible. While the duration of the tests was not reported, the three tests all have the same date, so it may be assumed the duration of each test was at most a matter of hours.

In a field study conducted by Dr. John Straube (Director of the Building Engineering Group, University of Waterloo in Waterloo, Canada) and Chris Schumacher, temperatures of a hydronically heated slab insulated with Ultra CBF rFOIL were compared to temperatures of a similar but uninsulated slab and slabs insulated with 1" expanded polystyrene (XPS) and 2" XPS. The study was conducted over a two-week period during cold winter weather, as described in their preliminary report. Via email, Dr. Straube informed us that his results were showing Ultra CBF rFOIL with an R-value of approximately R-2 and that, because preliminary results were not looking favorable, Covertech ended this study prematurely before more accurate results could be determined.

Canadian Building Envelope Science and Technology (CAN-BEST) conducted thermal testing of Ultra CBF rFOIL in "general conformance" with ASTM C236 "Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box." They reported a thermal resistance of R-3.83 (hr-ft^2-°F/Btu)[1] for an assembly of Ultra CBF rFOIL applied over a substrate having a "thermal conductance equivalent to that of a 150 mm (6") thick concrete slab." They did not report the R-values of either the Ultra CBF rFOIL or the substrate individually.[2] We note that testing was not conducted under conditions typical of a concrete slab. In particular, the assembly was arranged vertically with a temperature difference across it of 70°F. The R-value of reflective air spaces is strongly dependent on temperature, temperature difference across the air space, orientation of the specimen and direction of heat flow. For this reason, ASTM C236[3] recommends that conditions correspond to the naturally occurring environment. Since this was not the case, results are not relevant to its use as an under-slab insulation, even if the R-value of Ultra CBF rFOIL alone had been reported.

Bodycote Materials Testing Canada, Inc. (2001) conducted water vapor permeance testing. Measured permeance was 5.6 metric perms (0.098 US perms) before aging and 2.0 metric perms (0.034 US Perms) after aging. Bodycote's results indicate Ultra CBF rFOIL meets standards for vapor retarders in both the U.S. and Canada.[4]

Cost

One 4-foot by 125-foot roll of Ultra CBF rFOIL has a cost to contractors of $275, or about $0.55 per square foot. These costs do not include installation, which according to the manufacturer is "quick and easy," involving rolling out the product and taping along the seams.

Alternative Products and Strategies

According to the Reflective Insulation Manufacturers Association, there are many products intended for use in concrete floor systems that have one or more foil layers with layers of air-filled bubbles or flexible foam cores. We identified five manufacturers of bubble-type reflective insulations.

A common alternative as a vapor retarder is 6 mil polyethylene film, which has a permeance of 0.06 US perms or 3 metric perms (ASHRAE 2005), as compared to Ultra CBF rFOIL's permeance of 2.0 metric perms.[5] Membrane materials with permeance ratings of 0.0 perms are also available.

Case Studies

We are not aware of case studies evaluating the performance of Ultra CBF rFOIL used as an insulation for concrete slabs.

Suggestions for Further Research and Testing

It is known that polyethylene bubble wraps used in packaging lose their height in a matter of days or weeks under low pressures as the air diffuses through the polyethylene.[6] We suggest long-term compression testing to determine if Ultra CBF rFOIL will maintain the height of its bubble layers over time. If Ultra CBF rFOIL is not found to maintain its height over time, no other testing is recommended, as maintenance of the air layer is of critical importance to its insulating qualities.

Assuming the bubble layer passes long-term compression testing, we recommend testing Ultra CBF rFOIL in strict accordance with appropriate ASTM standards at temperatures and conditions that are representative of an under-slab application. In particular, we are interested in test results concerning any detrimental effect the product may have on heat loss due to thermal bridging (as suggested by thermal modeling) if installed under a full slab and over R-10 rigid insulation. If any further field studies are undertaken, we suggest careful planning to ensure sufficient data is gathered for calculation of F-factors.[7]

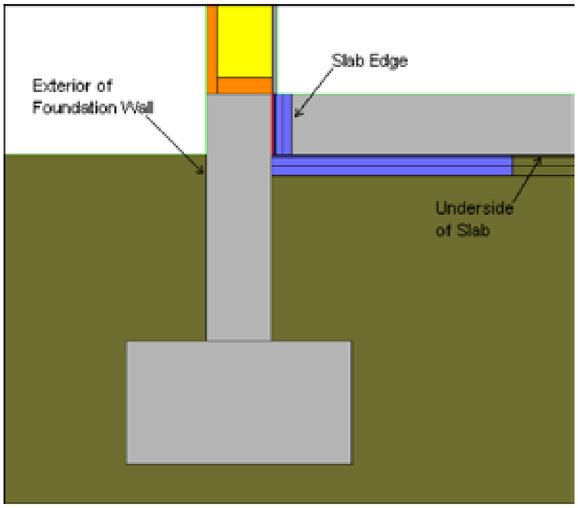
Additional Reviewer Comments

In general, for radiant barriers to be effective several conditions must be met. Any installation of reflective insulation not meeting the following criteria should be considered skeptically:

- There must be a sufficient air space or other transparent cavity in front of the reflective surface. In general, larger air spaces provide more insulating value.
- The reflective material must be clean; i.e. it must retain its reflectivity.
- There must be a good view factor across the cavity; i.e. the reflective surface must "see" the opposite side of the cavity more than it sees other surfaces such as, for example, the sides of the bubble cells.
- The effect of thermal bridging – in this case due to the highly conductive aluminum foil – must be relatively small.

The comments that follow are restricted to this particular type of product (bubble-foil-bubble insulation) used as slab insulation. We are not evaluating reflective insulations in general.

Figure 1.
Representation of a slab-on-grade foundation with 2" of expanded polystyrene insulation under the slab perimeter and at the slab edge.*



Representation in* ***Therm**, a thermal simulation tool developed by Lawrence Berkeley National Laboratory.*

Maintenance of an air gap in front of the reflective surface depends on the bubble layer withstanding pressure due to the weight of the concrete, furnishings and, for monolithic slabs, the house over time. Compression tests conducted by Intertek Testing Services on Ultra CBF rFOIL were short term, lasting less than a day. Over days, weeks or months, however, it is likely that the air in the bubbles gradually diffuses out, as has been found even in heavy-duty, nylon reinforced bubble wraps. On the positive side, the bubble layer does keep the foil layer clean.

Even if the air gaps are maintained, the insulating value of a reflective air space only 0.145" in height is small, much smaller than large reflective air spaces.[8] To evaluate the effectiveness of a bubble-foil-bubble insulation, we conducted preliminary thermal computer modeling of a 6-inch concrete slab-on-grade foundation with perimeter footing and R-19 wall, as illustrated in Figure 1.[9] In this modeling we compare bubble-foil-bubble insulation to 1" and 2" layers of extruded polystyrene (XPS) insulation. These results did not quantify the potential for energy savings, but compared simulated F-factors for various levels of insulation for this particular slab configuration at an indoor temperature of 70°F and outdoor condition of 30°F and for both an unheated slab and a slab heated to an average of 90°F (similar to the slab temperature in the study by Straube and Schumacher 2001).

We emphasize that many of the insulation levels we examined – in particular the substitution of Ultra CBF rFOIL for any code-required insulation – do not meet any state energy codes that we are aware of, nor the International Energy Conservation Code (IECC), which most states are either adopting or have already adopted, nor the International Residential Code (IRC), which has its own energy requirements for residences. We are not recommending any insulation levels in this review, and certainly not the replacement of code-required insulation levels with Ultra CBF rFOIL.

This preliminary modeling suggested the

following points, assuming the bubble air gaps are maintained:

- Bubble-foil-bubble reflective insulation provides some insulation value in most, but not all, of the cases we examined. At best, this insulation value was only slightly better than two layers of bubble wrap without the reflective foil. Its effectiveness varied depending on where it was installed and whether it was installed in conjunction with other insulation.

- The reflectivity of the foil had a small beneficial effect, but in some cases this benefit was outweighed by the detriment of thermal bridging.[10] In under-slab applications, performance of bubble-foil-bubble insulation declined with increasing levels of rigid insulation due to increased thermal bridging.

- The least effective application of a bubble-foil-bubble insulation from an energy standpoint is an installation under the full slab area on top of R-10 insulation. In this case, heat loss from the slab may be *increased* by as much as 10% due to the thermal bridge effect of the aluminum foil, as illustrated in Figure 2. In other words, the R-value of the slab insulation system would be *decreased* by the addition of the bubble-foil-bubble insulation.

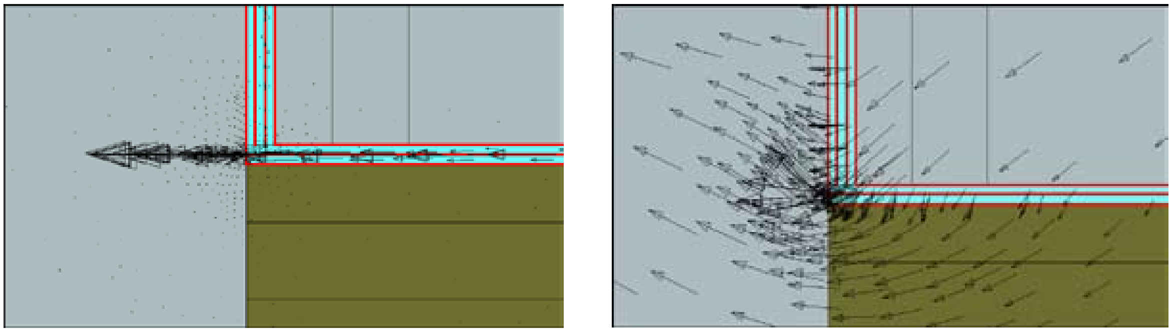
- When used in conjunction with insulation levels required by the Washington State Energy Code[11] (R-10), the most effective location for a bubble-foil-bubble insulation from an energy standpoint is on the vertical surfaces of the slab's foundation wall or footing. Nevertheless, its insulation value installed here is still quite small, only slightly better than two layers of bubble wrap without a foil layer.[12]

- We found no basis for the manufacturer's claim of 77% reduction in heat loss due to Ultra CBF rFOIL in an under-slab application. This heat loss reduction significantly exceeds even that of 2" extruded polystyrene insulation installed under the full slab, while the insulating value of Ultra CBF rFOIL is much less.

Conclusion

The insulating value of this type of product varies depending on what other insulation it is combined with and where it is installed on the slab. At best, its insulating value was only slightly better than two layers of bubble wrap without the reflective foil layer, or a maximum

Figure 2.
Heat flux vectors illustrate thermal bridging due to the aluminum foil by comparing two cases: (a) central layer of aluminum foil between two air spaces and (b) central layer of polyethylene between two air spaces. Within each figure, larger arrowheads indicate greater heat flux. In (a) the arrowheads along the aluminum foil are so large, that the other arrows look like dots in comparison.



(a) **(b)**

possible R-value of 1.5 to 2.0. This maximum is unlikely to be achieved in an under-slab application and impossible if the air gaps are not maintained.

In the particular case of Ultra CBF rFOIL installed as a vapor barrier under a slab fully insulated with R-10 rigid insulation, Ultra CBF rFOIL could *increase* heat loss due to thermal bridging, even if the air gaps are maintained; i.e. its R-value is negative in this application. At worst, if the bubble layer air gaps are not maintained (due to air diffusing out under the weight of the slab and furnishings – which is very likely in the long term), Ultra CBF rFOIL would have no effect other than increasing heat loss due to thermal bridging and providing a vapor retarder. Other vapor retarders, such as polyethylene, typically have lower cost and do not negatively impact energy use.

We conclude that an under-slab installation is not a good application for this type of product, even if only used to replace a vapor retarder.

References

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Straube, John, and Chris Schumacher, "Field Study of Covertech's Concrete Barrier rFOIL Used Below Radiant Floor Slabs," May 2001.

Yarbrough, David, personal email communication, 2005. Yarbrough performed calculations of R-values for several cases of small reflective air spaces based on typical conditions we provided him. The tabulated R-values for air spaces found in ASHRAE (2005) are based on Yarbrough's method.

Additional Information

Northwest businesses and electric utilities can contact the EnergyIdeas Clearinghouse for additional information on insulation or other energy technologies or products. Contact:

Phone: 1-800-872-3568
Email: info@EnergyIdeas.org
Website: www.EnergyIdeas.org

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Reviewer

Carolyn Roos, Ph.D.
WSU Extension Energy Program

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End Notes

1 *We calculate an R-value of R-2.68, rather than R-3.83, for the combined concrete substrate plus Ultra CBF rFOIL, based on CAN-BEST's reported data (486.0 Btu/h heat flow through a 24 ft² specimen with surface temperatures of 60.1°F and 5.9°F.) Since the R-value of 6 inches of concrete ranges from about R-0.3 to R-0.8, this suggests an R-value for the Ultra CBF rFOIL of R-1.9 to R-2.4* ***under the conditions of this test****. We emphasize that CAN-BEST's test conditions did not represent typical under-slab conditions.*

2 *The conductance of concrete varies depending on factors such as the aggregate used and density, so the R-value of Ultra CBF rFOIL alone cannot be determined from the information given.*

3 *ASTM C236 has been superseded by ASTM C1363.*

4 *The relevant Canadian standard is CAN/CGSB-51-M89 "Vapor Barrier Sheet, excluding Polyethylene, for Use in Building Construction." In the U.S., vapor retarders are typically specified according to ASTM E-1745-97(2004) "Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs."*

5 *Lower values of permeance indicate less moisture transmission.*

6 *AirCap Barrier Bubble packaging by Sealed Air Limited (www.sealedair.com) loses 5% of its thickness in 15 days under 0.3 psi pressure, compared to 49% thickness loss for a "non-barrier" bubble wrap. The durability of AirCap "Barrier Bubble" has been achieved by adding a layer of nylon to reinforce the polyethylene, which substantially increases the longevity of the bubble under pressure.*

7 *The F-factor (also known as F-value) is the perimeter heat loss factor, with inch-pound units of Btu/h/ft/°F. In heat loss calculations for slabs, basements and below grade walls, the F-factor is used instead of the U-value because heat loss from these elements is primarily related to the building perimeter rather than the floor area.*

8 *The calculated R-value for two 0.145" reflective air spaces (under similar conditions as the Ultra CBF rFOIL would experience in an under-slab application) is R-1.5, based on calculations by Yarbrough (2005). As an example of a larger reflective air space, one horizontally oriented 3.5 inch air space at 90°F with 10°F temperature difference, downward heat flow, and similar reflectivity as Ultra CBF rFOIL, would have an R-value of R-8.19 (ASHRAE 2005, chapter "Thermal and Water Vapor Transmission Data").*

9 *For more information, contact the EnergyIdeas Clearinghouse (www.EnergyIdeas.org). In our preliminary study, we used the finite element, steady state, two-dimensional thermal simulation tool* ***Therm*** *developed by Lawrence Berkeley National Laboratory to simulate heat transfer of a 6" concrete slab-on-grade foundation with perimeter footing and R-19 wall, as shown in Figure 1.*

10 *A thermal bridge is a high conductivity material used in a building structure that lowers the overall thermal insulation of the structure. A thermal bridge – in this case aluminum foil – essentially acts as a "channel" for heat transfer. A common example of a thermal bridge is metal studs in a wall. A highly conductive material oriented parallel to heat flow will result in thermal bridging, while a conductive material oriented perpendicular to heat flow generally will not. Our results indicate that Ultra CBF rFOIL acts as a thermal bridge in under-slab installations, but not when installed vertically on foundation walls.*

11 ***Washington State Energy Code****, 2004 Edition, Chapter 51-11 WAC, when using the prescriptive method. Refer to Tables 6-1 and 13-1. The Energy Code is available online at: www.energy.wsu.edu/code/code_support.cfm*

12 *Keep in mind that a vapor retarder on a slab's perimeter footing should be carefully installed in accordance with local codes and accepted practice. For more information on use of vapor retarders with slab foundations, refer to the publication* ***Read This Before You Design, Build or Renovate*** *by Building Science Corporation, available online at: www.buildingscienceconsulting.com/resources/mold/Read_This_Before_You_Design_Build_or_Renovate.pdf*

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