

FINAL REPORT

ICYNENE CASE STUDY

**Evaluation of Icynene®
as an Insulating and Air-Sealing System**

Prepared for

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None of the major building codes, including the *Model Energy Code*, quantify acceptable levels of air infiltration in residential structures.⁹ The *Model Energy Code* does make reference to the control of air leakage by caulking and sealing the building envelope "in an approved manner" (MEC-92, Section 602.3.2), but this passing reference in no way establishes required techniques or materials to restrict air infiltration/exfiltration, nor does the code require or suggest a test to determine the air tightness of a residential structure.

Standardized test data indicate that the air tightness of Icynene insulation is comparable to the air tightness of conventional air infiltration barriers, more commonly referred to as "housewraps."¹⁰ Because the codes do not make specific requirements for the air tightness of a house, clearly the elimination of a separate air barrier when Icynene foam insulation is employed is acceptable building practice.¹¹

3.3 Vapor Retarders

All four of the major model codes refer to either the *Model Energy Code* or an ASTM standard on vapor retarders. Both require a vapor retarder with at least a 1.0 perm rating on the warm-in-winter side of the building envelope (except in hot and humid climates). It is customary for the major codes not to specify material or techniques to achieve various requirements and this holds true for the 1.0 perm rating--no particular materials or techniques are specified.

Many builders and building inspectors do not fully understand the nature of moisture movement into and through the building envelope. Moisture can move into the building envelope in two ways--as the result of a diffusion gradient from areas of high moisture concentration to areas of lower moisture concentration or along with air as it infiltrates or exfiltrates the building envelope. Moisture movement associated with convection can dwarf the moisture movement by diffusion:

"It has been calculated that the movement of water vapour through a 2 cm (3/4") square hole as a result of a 10 pascal air pressure differential is 100 times greater than the movement of water vapour as a result of vapour diffusion through a 1 square meter (10 sq. ft.) sheet of interior gypsum board."¹²

⁹ The *Model Energy Code* was developed by the major code officials organizations as a reference and guide for the major model and local building codes. Section 602.3.2 of the *1992 Model Energy Code* addresses air infiltration in the building envelope.

¹⁰ Housewraps are typically spun-bonded polyolefin sheet goods such as Typar™ or Tyvek™. They are stapled to the exterior of the building shell after the shell is sheathed and before it is sided.

¹¹ One qualification made by Icynene, Inc. is the necessity of caulking areas of air infiltration which cavity foaming does not address--primarily the contact line between the bottom plate of exterior walls and the floor deck or other areas where framing to framing contact could lead to a point source of air infiltration. These limited areas are readily accessible during more than one stage of the construction process and can be easily caulked from the inside of the structure.

¹² Ltsiburek, Joseph, *Building Science*, Seminar text produced by Building Science Corporation. Cambridge, MA, 1988.

Clearly, stopping the moisture carried by air leakage is more important than stopping the moisture carried by diffusion gradients.

And yet, the most commonly used 1.0 perm vapor retarders, polyethylene sheeting and the kraft paper facing on fiberglass batts, only address diffusive moisture movement without careful and complete air-sealing details. Application of vapor retarders without attention to the air tightness of the building envelope is equivalent to turning off a water spicket instead of fixing a broken water main. Even small points of air leakage can carry enough moisture-laden air to dwarf the amount of moisture movement retarded by a 1.0 perm vapor retarder. This is not to say that in certain climates, 1.0 perm vapor retarders are not an important part of building envelope integrity. The focus, however, should first and primarily be on addressing the air tightness of a building envelope.

Standardized test data indicate that the perm rating of Icynene foam alone does not achieve the widely accepted 1.0 perm rating for moisture permeance in building envelopes. The moisture permeance of 3 or even 5 inches of Icynene foam (16 and 10 perms, respectively) is insufficient to meet the vapor retarder requirement. Icynene's control of convective moisture movement, however, permits the use of a vapor retardant primer paint on the interior gypsum board to control diffusive vapor movement. The use of a 1.0 perm rated paint primer is a more cost-effective form of vapor retardance than 6 mil polyethylene sheeting as it does not require a separate task. At the local level, however, convincing local building inspectors that 6 mil poly can be replaced by a vapor retardant primer paint if Icynene is the insulation material may be difficult. Anecdotal evidence suggests that local building inspectors are less accepting of the vapor retardant primer because verification of its use is more difficult and inspection of the vapor retarder cannot be accomplished at the same time as inspection of the insulation.

Phone interviews held with eight recognized experts in the field of moisture movement in building envelopes revealed that most felt that only in certain cold climates would a separate 1.0 perm vapor retarder be required with an insulation material with Icynene's properties. How cold a climate needed to be before a 1.0 perm vapor retarder was required with Icynene was a question for which none of the experts contacted felt that sufficient information was available. Several suggested that computer modeling might provide guidance. All emphasized that the primary culprit for moisture problems in building envelopes was not diffusive moisture movement--the moisture movement that vapor retarders are designed to control--but convective moisture movement--moisture movement associated with air infiltration/exfiltration that air barriers are designed to control.

Computer modeling of moisture movement in walls using a program (MOIST) developed by Doug Burch of the National Institute of Standards and Technology (NIST) suggested that a 1.0 perm rating was not required when Icynene insulation was used, except in climates as cold or colder than Madison, Wisconsin (7500 degree days).¹³ This conclusion was in general agreement with other computer modeling of moisture movement in building envelopes performed

¹³ The MOIST computer modeling performed in this case study was done with limited variation of building envelope components other than the insulation; the effects of various types of exterior sheathing, siding, etc. would be likely to have significant impact on moisture movement and accumulation.

in Canada. Further modeling would clearly provide a better understanding of the specific conditions for which a separate 1.0 perm vapor retarder are indicated with the use of different insulating materials and other building envelope components. Additionally, other conditions such as indoor and outdoor relative humidity and active and passive ventilation can have substantial impact on moisture movement and must be considered in the design of the building and its envelope.

Table 2
Installed Cost Comparison of Insulations

Material	Installed Cost (sq. ft.) Equivalent Thickness
Fiberglass (unfaced) ¹⁴	\$.50
Spray Urethane Foams	\$1.25
Icynene System	\$1.00 - \$1.09
Functionally Equivalent Fiberglass System	\$1.05 - \$1.30
Polyethylene Wrap ¹⁵	\$.09
Housewrap	\$.16
Professional Air-Sealing	\$.30 - \$.50
Standard Paint Primer (perm rating > 1.0)	\$.03
Vapor Retardant Primer (perm rating ≤ 1.0)	\$.04
Sources: 1993 Means Residential Cost Data; Journal of Light Construction, Vol. 10, No. 9; "Assessment of Foam-in-Place Urethane Foam Insulations Used in Buildings," ORNL/Sub/86-56525/1.	

3.4 Functionally Equivalent Cost Comparison of Icynene and Fiberglass Insulation

Table 2 presents the installed costs associated with Icynene, fiberglass, other spray foams, and related building envelope materials.¹⁶ At face value, the installed cost of Icynene is twice that of fiberglass. However, if the installed cost of additional materials required for fiberglass to be

¹⁴ The installed cost of kraft-faced batt insulation was not available. Presumably the tar-impregnated paper and staples required for installation and the added labor of stapling the faced installation would increase the installed cost of faced compared to unfaced batts.

¹⁵ Not generally included in the cost of installing a polyethylene vapor retarder are measures performed during the framing process that ensure a continuous barrier. These details include wrapping first and second floor rim joists and placing a poly strip above all top floor interior walls. While these measures are not standard practice in the U.S., they are routinely done by Canadian framing crews and by more energy-conscious builders in cold climate regions of the U.S. The cost of these vapor retarding details are hidden in framing costs and not a part of the cost as presented in this table.

¹⁶ The installed cost of Icynene is for the open-cavity, spray-applied application. Independently-determined, installed cost figures for the closed-cavity application were not available.