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Field Performance of an Air Infiltration Barrier

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ABSTRACT: A spun-bonded polyolefin air infiltration barrier (AIB) was installed immediately beneath the siding of a 5-year-old, ranch-style house [conventional comparison house (CCH)]. The AIB reduced the heating energy consumption by 24% during the first heating season and is expected to reduce the heating load by 28% over the remaining life of the house.

This test confirmed earlier field studies and allowed the development of the mechanism by which AIBs function and the recommendation of required AIB physical properties.

KEY WORDS: air infiltration barrier, AIB, heating energy conservation, AIB performance mechanism, AIB recommended physical properties

Objective

1. To determine the effectiveness of a spun-bonded polyolefin air infiltration barrier (AIB) sheet structure in reducing energy consumption when installed in a typical home.
2. To establish recommended physical properties required for AIBs used in typical construction.

Summary of Results

The heating energy consumption of a typical ranch-style, 111-m^2 (1195-ft^2) conventional comparison house (CCH), built by the National Association of Home Builders Research Foundation (NAHB-RF), was monitored accurately

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for 5 years. The installation of an AIB reduced the consumption of energy in this CCH by 24% for the first heating season (1982-1983). This AIB is expected to reduce the cost of the heating load of living spaces in this house by 28% (compared to no AIB) over the remaining life of the house. These results were normalized for degree days and are based on the energy use history of the house for the 5 years immediately preceding the AIB installation.

Observations from this test installation, in addition to other field studies, suggested the recommendation of minimum physical property requirements for an AIB.

Definition—Air Infiltration Barrier

When installed, an AIB is a continuous envelope with an unbroken surface immediately beneath the siding (on the opposite side of the studs from a vapor barrier), has a gas permeability between certain upper and lower limits, and is sealed at the edges to the structure in such a manner as to ensure that air which transfers through the wall cavity must pass through the AIB.

Background

In Mt. Airy, Maryland, the NAHB-RF in 1977 built a standard ranch-style, three-bedroom house (CCH) with 111 m^2 (1195 ft^2) of conditioned living space on the first floor and an equal space in the partially conditioned full basement. This house has been continuously occupied by the same family of four since February, 1978. The house is all-electric, and each service circuit has an individual meter. Accurate data on weather and energy consumption on each circuit have been kept on a monthly basis over the past 6 years for the CCH. This house was constructed using standard materials and practices with usual, but no special, attention to detail. The walls of the CCH were insulated with kraft-faced R-11 fiber glass batts and the ceiling with blown fiber glass to R-19 with a 0.10-mm (4-mil) polyethylene vapor barrier just above the gypsum board ceiling. CCH served as the control unit for the Energy Efficient Residence No. 1 (EER-1) that NAHB-RF constructed next door. Results of retrofitting EER-1 with an AIB will be reported at a later date.

Under contract to the DuPont Co., NAHB-RF removed from the CCH the existing brick veneer and aluminum siding, enclosed and sealed exterior walls on the first floor with a spun-bonded polyolefin AIB fabric, and replaced the brick veneer and aluminum siding.

Figures 1A and 1B present schematic drawings of the front and rear walls of the CCH after installation of the AIB. This concept is representative of the entire AIB installation. It should be emphasized that much care was taken to ensure that the AIB fabric was sealed at the edges and around openings (for example, windows, doors, and service penetrations).

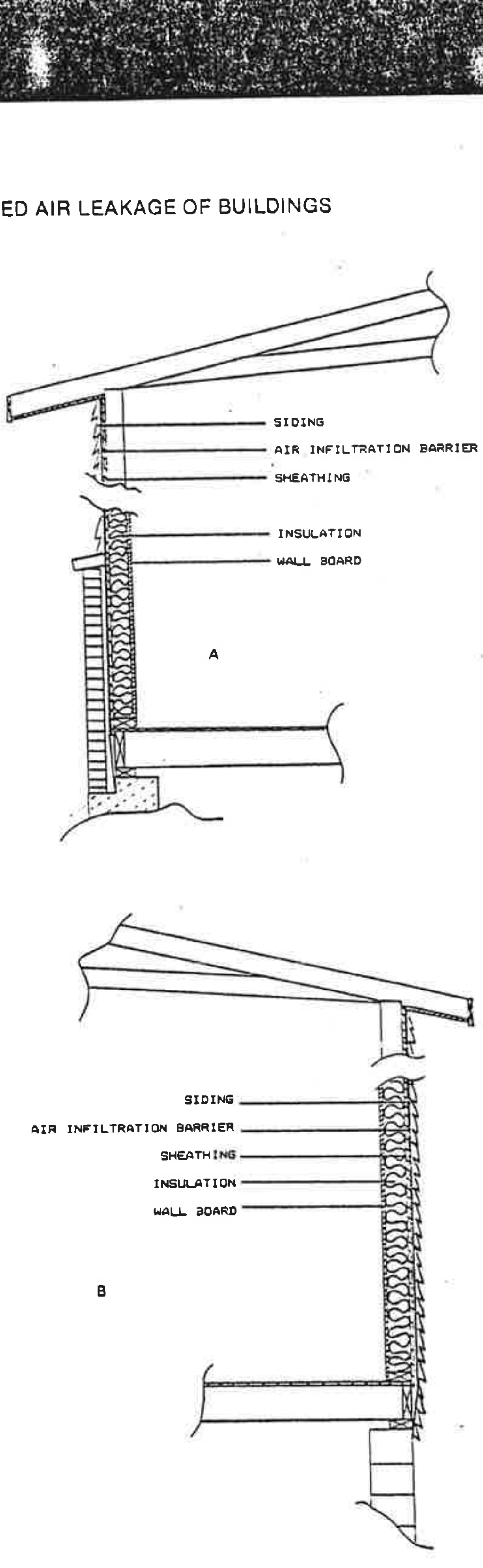

FIG. 1—(A) *Section at front wall of CCH;* (B) *Section at rear wall of CCH.*

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The Mechanism by Which AIBs Function

An AIB works by controlling the movement of outdoor air through the wall as well as into and out of the wall cavity. A review of the function of the building envelope, of which the wall is a major and complex part, is useful in defining the function of an AIB in this envelope system.

The Function of Building Envelopes

For purposes of this paper, only the wall portion of the envelope will be addressed. Relative to comfort conditioning, the exterior wall serves two major functions:

1. Controls conductive heat loss/gain from the conditioned living space (insulation).
2. Controls leakage of unconditioned air into the conditioned living space or leakage of conditioned air from the living space (infiltration/exfiltration).

The major thrust on which the building industry has concentrated was reducing the cost of energy expended to condition the air inside a house. And, since the envelope (the wall) can be a principal source of loss of conditioned inside air, building walls tighter has been an important element in energy saving design and construction. Work on this aspect of reducing air transfer through the envelope was and is correct and should be continued.

The evolution of a wall system into today's technology has involved attempts to stop the movement of air mass into and through the wall, which includes siding, insulation, sheathing, vapor barriers, and caulking. Common methods used in the past to reduce the excessive envelope air infiltration include attempts to stop air infiltration completely. However, no air movement in a wall cavity also may lead to structural damage if moisture becomes trapped there. Liquid water in a wall cavity generally will require some air mass transfer for any significant rate of evaporation and removal of the water.

Function of an AIB

An air infiltration barrier functions to prevent localized high velocity air from moving through the envelope while allowing a controlled, very low velocity air mass exchange within the wall cavity. This is accomplished by:

1. The AIBs having a uniform air permeability, between specified limits, over its entire surface to control the air mass diffusion into and out of the envelope.
2. Having no unintended breaks in the surface of the AIB.
3. Sealing the edges of the AIB to the structure in such a way as to prevent air leakage into or out of the wall cavity at the edges.

all of CCH.

The major advantage of an AIB is to allow a limited volume of air exchange between the wall cavity and the outdoors over a large area, eliminating high velocity air movement at localized points. This promotes evaporation of any moisture that may have condensed in the wall cavity and transfer of the moisture vapor out of the wall cavities. Thus, the AIB prevents excessive air mass transfer through the building envelope, which reduces the cost of conditioning inside air, while providing sufficient air mass transfer to ensure against accumulation of moisture vapor in the wall cavity.

Air Infiltration and Air Leakage in the CCH

Air Infiltration

At the time CCH was built, a series of SF6 tracer gas tests were run over several months while the house was still unoccupied. These tests established the average air infiltration rate to be 0.35 air changes per hour (ACH). After the AIB was installed in the CCH, a series of tests using a perfluorocarbon (PFT) tracer gas technique developed by Brookhaven National Laboratories (BNL) were conducted under occupied conditions over a 9-month period (September, 1982, to May, 1983). BNL developed a math model correlation between the SF6 tracer gas and PFT that indicates that the two sets of test results are directly correlatable. The PFT tests indicated an average infiltration rate of 0.22 ACH, a reduction of about 35% in air infiltration (Table 1).

Particularly interesting was the finding in the second series of tests that the rate of air exchange between the basement and the first floor was at least 15 times greater than that between the first floor and the outside air.[3]

TABLE 1—*BNL summary of CCH infiltration results.*

Sampling Period	Air Exchange Rates, h^{-1}		Air Infiltration Rates, h^{-1}		
	Basement to First Floor	First Floor to Basement	Basement	First Floor	Total
9/1 to 10/1/82	...	...	...	...	0.10
10/5 to 11/1/82	...	...	...	...	0.12
11/1 to 12/1/82	...	...	...	...	0.18
12/1 to 12/31/82	0.37	0.16	0.27	0.15	0.21
12/31 to 1/31/83	0.69	0.30	0.38	0.04	0.22
1/31 to 3/1/83	0.53	0.19	0.31	0.08	0.20
3/1 to 4/1/83	0.49	0.15	0.26	0.15	0.21
4/1 to 5/1/83	0.32	0.09	0.20	0.29	0.24
5/1 to 6/1/83	0.15	0.04	0.14	0.62	0.37

[3]Unpublished report from the Brookhaven National Laboratory to R. K. Yingling, National Association of Home Builders Research Foundation, 9 Feb. 1984.

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0.15	0.21
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0.62	0.37

…o R. K. Yingling, National

Air Leakage

Air leakage values were determined for the CCH by blower door tests just before and just after the AIB installation. The results obtained are indicated in Table 2.

These results tent to confirm those of the tracer gas tests that the air exchange rate of this house was reduced by at least one third with the installation of the AIB. These results infer a significant reduction in heating energy demand due to the installation of the AIB.

Heating Energy Demand of CCH with an AIB

Figure 2 presents two energy consumption curves for CCH. The upper curve (circles) is the average heating energy consumed normalized for degree

TABLE 2—*Blower door test results for CCH. ACH.*

	Before AIB		After AIB	
	At 50 Pa	At 4 Pa	At 50 Pa	At 4 Pa
House pressurized	10.2	1.4	6.0	0.6
House depressurized	6.9	1.4	5.1	0.9
Average	8.6	1.4	5.6	0.8

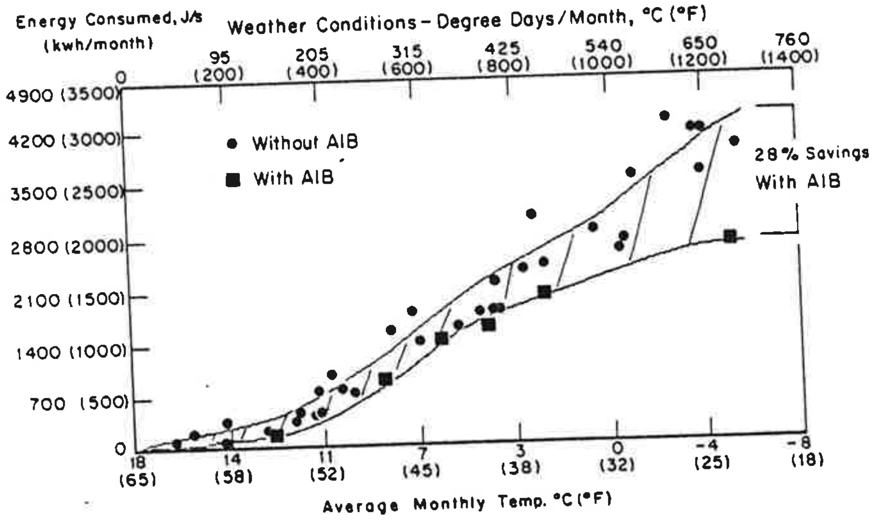

FIG. 2—*Energy consumption in the Mt. Airy house with and without AIB.*

days [base: 18.3°C (65°F)] on a monthly basis before the AIB was installed. The scatter about the average energy use rate curve is explained by variations in wind conditions about the CCH. As the wind increases about the CCH, the more conditioned indoor air will be forced out of the house at a given outdoor air temperature. Thus, various average monthly wind velocities can result in different amounts of energy consumed for a specified degree day month.

The lower curve (squares) represents data points for the first heating season of the CCH after installation of the AIB. Two observations should be noted about this curve:

1. All points on this curve are below all points on the upper curve (before the AIB was installed), which substantiates that the AIB resulted in a significant reduction in air infiltration.
2. All points lie close to the smooth curve, which indicates that most of the air mass passing through the envelope moved through the walls that the AIB now controls. If these points did not lie on a smooth curve, it would indicate that the air infiltration through the envelope was not controlled by the AIB.

The difference between the two curves represents a projected 28% energy savings for the CCH over the life of the house. For this particular heating season, the savings in energy consumption was 24%. The payback time on this low cost system (materials and labor) would be about two heating seasons for this house, assuming about $200 for labor and materials for installing the AIB on a new home.

TABLE 3—*Recommended air flow limits, m/s (ft/min.).*

Lower Limit		Upper Limit	
At 50Pa	At 4Pa	At 50Pa	At 4Pa
5.0E-4 (0.10)	1.0E-4 (0.02)	15E-4 (0.30)	3.5E-4 (0.07)

TABLE 4—*Minimum average strength properties recommended for sheet material ATBs.*

Physical Property	Min Value	Method
2.5-cm strip tensile: Strength	6.8 kg (15 lb)	ASTM D 1682-64 (1975)[a]
Elongation	15%	. . .
Elmendorf tear strength	0.3 kg (0.7 lb)	ASTM D 1424-83[b]
Hydrostatic pressure	25 cm (10 in.)	AATCC 127-77

[a]Methods for Breaking Load and Elongation of Textile Fabrics.
[b]Method for Tear Resistance of Woven Fabrics by Falling-Pendulum (Elmendorf) Apparatus.

Conclusion

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[1]Infiltec, Waynesboro, VA
[2]Red Wing, Rome, NY 13

Conclusion

As demonstrated in this test, an AIB, such as the spun-bonded fabric used, appears to offer a very cost-effective method to significantly reduce energy consumption in a conventionally constructed house.

AIB Physical Property Requirements

The principal physical property is limited uniform air permeability. Table 3 indicates AIB air permeability limits recommended for consideration.

In addition, for sheet material AIBs, the minimum average strength properties are recommended as shown in Table 4.

DISCUSSION

D. Saum[1] *(written discussion)*—Was the siding that was put up identical to the siding that was removed from the house?

D. Luebs and R. Weimar (authors' closure)—Yes.

T. Brennan[2] *(written discussion)*—During your slide sequence it was clear that you uncovered and sealed a variety of large openings through the band joist and around windows and doors. What would be the effect of sealing only those large holes by more conventional means (caulk, foam, polyethylene film) and ignoring the more circuitous paths through the sheathing and framing?

D. Luebs and R. Weimar (authors' closure)—The "variety of large openings through the band joist" to which you referred were not themselves sealed. Only the air infiltration barrier itself was sealed to the wall perimeters.

Sealing those "large holes" by conventional means would have brought the house to the original design specifications while reducing the air exchange rates in the house. The significant advantage of an air infiltration barrier is that its installation replaces having to correct errors, many of which may not be caught in the normal construction process.

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[2]Red Wing, Rome, NY 13440.