#3671

Draft-Free Construction

(1) Performance tests of tight homes over a 2 year period

Airtightness is a measure of the resistance to air leakage provided by the building envelope. For leakage to occur, holes must be present in the envelope along with a pressure differential to drive the flow. In residential construction pressure differentials are created by natural forces, such as wind and stack action, and by mechanical systems such as ventilation equipment, furnaces and other household appliances.

From a building science perspective, air leakage has several negative effects. The most obvious is increased energy consumption for both the heating and cooling loads of the structure. The second and perhaps most important effect is moisture movement into the envelope.

It is generally recognized that the prime mechanism for moisture transport is air exfiltration. This process can deposit significant quantities of moisture in the construction, usually concentrated in locations around the leakage sites. Water accumulations can accelerate rotting of wood components, insulation wetting and staining/destruction of interior surfaces.

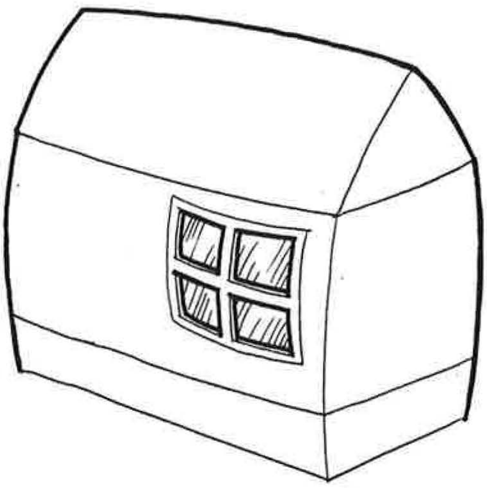
Air leakage can reduce comfort levels in a home if the infiltrating cold air is felt by the occupants. (This is why we prefer the term *draft-proof* construction rather than airtight).

Air infiltration can also degrade the quality of the indoor air if leakage occurs through an area where pollutants are present.

Thus building science, comfort and air quality considerations suggest that it is desirable to maximize the airtightness of a house. In practice, of course, air leakage cannot be eliminated but only controlled within defined limits. The National Building Code of Canada does not yet contain any quantitative requirements for residential airtightness.

The primary mechanism used to control air leakage through building envelopes is the air barrier which may consist of a single material or an assembly of materials. The main requirements for air barriers are generally defined as:

- *low permeability to air flow*
- *structural strength to withstand the pressure loads*
- *continuity to reduce leakage*
- *sufficiently durable to last the life of the building*
- *rigid enough to provide pressure equalization behind exterior cladding*



In new residential construction, polyethylene is the most commonly used material. Joints in the poly may be sealed with caulking or simply stapled in place. In most applications, it is also used as the vapour barrier.

A second system which has gained acceptance is the Airtight Drywall Approach (ADA) which relies on the drywall to function as the air barrier with paint or poly as the vapour barrier. Leakage at joints between major envelope components is controlled through the use of strategically located gaskets.

Airtightness tests

Tests were performed over two years on 20 new houses as part of the Flair Homes Energy Demo/CHBA Flair Mark XIV project in Winnipeg. The houses had similar floor plans and were constructed by the same builder. Polyethylene was used as the air/vapour barrier in 6 of the houses while 14 used the Airtight Drywall Approach (ADA).

Both systems met the airtightness requirements of the R-2000 Program. The tightest structures were the double wall houses. No significant or permanent change in airtightness was observed for any of the houses after the two year monitoring period. Variations which did occur were judged to be due to normal house behaviour.

DRAFT-FREE CONSTRUCTION WHAT'S IN A NAME?

We use the term ***airtight*** *construction regularly, but what image does it leave the home buyer? How often do you hear concerns about the air inside? will it get stuffy? can you open the windows?*

Instead of stressing airtightness (which is what is required for proper construction) we should be stressing the consequences of airtight construction. The average person can understand a ***draft-free*** *environment. It's what we all strive for.*

Draft-free *construction explains our objectives, tells homeowners what they will get without frightening them. Why don't we insist on calling it* ***draft-free****?*

Each house was tested with a blower door two to four times a year. Measured airtightness levels ranged from 0.43 to 1.78 ACH at 50 Pascals.

The tightest houses were the four built with double wall construction, where the air/vapour barrier is sandwiched between the two walls. The average was 0.849 ACH when first tested and 0.905 ACH after two years.

The ADA houses had an average 1.227 ACH at the beginning and 1.277 ACH after two years.

The other homes using poly were 1.148 ACH at the beginning and 1.149 ACH after two years.

Houses with similar air barrier systems performed in a similar way. In other words, there was little change.

The use of stucco as an exterior wall finish (common on the Prairies) was found to produce a noticeable improvement in airtightness for the ADA houses. It was not observed to have as big an impact on airtightness of the double wall houses which used polyethylene as the air/vapour barrier.

Where was there air leakage?

Only a few areas were consistently noted as sources.

In the ADA houses the electrical outlets on exterior walls, were consistent leakage sources. Commercially available semi-rigid "poly-pans" with foam gasket under the cover plate were used in these houses. Wire penetrations into the pan were caulked and reasonable care was taken to insure a tight fit between the pan and drywall. However, the flexibility of the pan material is believed to have permitted leakage between the flange face and the drywall.

Window leakage was also frequently noted, particularly through joints in the frame, between the frame and casing and along the weatherstripping. The frequency of window source leakage has increased in the houses during the monitoring period indicating a gradual degradation of performance at this location.

Leakage was also noted along baseboards in the cantilevered bay windows in bedrooms in some houses.

Other leakage areas less frequently noted were service penetrations for ventilation ducts and, on the two

conventional houses, plumbing stacks and chimney penetrations.

There is considerable debate about which system is the most appropriate for Canadian conditions. The so called "poly approach" is usually viewed as a more traditional and hence better understood technique for new construction while the ADA approach is argued to be better able to withstand the pressure forces to which the air barrier will be exposed.

One reason for the debate over the air barrier design is the requirement for structural strength. The question is how large are the forces acting on the structure?

In residential construction, pressure loads due to stack effect seldom exceed 10 to 20 Pascals while loads due to the mechanical systems may be slightly larger. Wind action however, can generate pressures on an exposed building surface of over 1000 Pascals. If the air barrier is intended to withstand the entire pressure differential, then its structural design will be determined by the wind loads on the building.

One point that must be kept in mind is that airtightness is not a fixed performance characteristic of a structure but can fluctuate over time. However, major changes usually occur in the first year after construction.

PRESSURES ON RESIDENTIAL BUILDINGS

City	Design Pressures (pascals)
Winnipeg	880
Vancouver	1160
Edmonton	840
Toronto	1010
Halifax	1090
Coal Harbour NWT	2520
Minimum (several locations)	500

(These are the design pressures that the building envelope has to withstand)

The monitoring results lead to some interesting observations concerning the air barrier systems demonstrated in the project. First, it is clear that both the poly and ADA systems are capable of meeting the airtightness requirements of the R-2000 Standard. All of the systems met the Standard prior to the application of stucco which indicates they could also have met it if other, more permeable cladding systems had been used.

None of the air barrier systems demonstrated any significant change in airtightness during the monitoring period once the stucco had been applied. Although the airtightness levels were observed to fluctuate, there was no systematic tendency to increase or decrease. The observed variations in airtightness for the project houses were small compared to the range of airtightness levels measured for new, conventional Canadian construction.

The observed variations in airtightness of the houses could have resulted from several factors including: swelling and shrinking of wood framing members, degradation of weatherstripping, differential movement of the foundation, and measurement error.

Stucco, which was used on three of the four walls of each house, was observed to have a significant effect on the airtightness of all but the double wall houses. The ADA houses, with or without the TYVEK air retarder, displayed significant reductions in their measured airtightness with the application of stucco while the double wall houses using poly did not exhibit equivalent reductions.

In general, the performance of builders tends to follow a characteristic pattern or learning curve. In the first few houses significant leakage will be found at certain locations (depending on the envelope systems). Once these major leakage areas are identified, the builder is usually able to reach the R-2000 airtightness requirement fairly consistently, only deviating when a new system or new subtrades are used or a "blunder" is made.

Houses which do not meet the R-2000 requirement usually fail because a few major "holes" have been left unsealed. One way for builders to reduce the cost of "airtight construction" may be through the use of a simple "leak detection system". Its purpose would be to identify significant leakage areas so they could be sealed.

The airtightness monitoring program described in this study has not observed any significant change or degradation in measured airtightness in 20 relatively airtight houses over a two year period. Although testing is continuing, the results to date indicate that there is a need to examine the structural requirements for residential air barrier systems.

This item outlines the findings noted in the Flair Homes Project Report No. 5: "Airtightness Performance of 20 Detached Houses Over a Two-Year Period" prepared by Gary Proskiw of Unies Ltd., For information or to obtain a copy, contact: EMR, Residential Energy Management Division, Ottawa, Ont. K1A 0E4

Draft-Free Construction
(2) How durable are polyethylene air/vapour barriers?

The R-2000 Program has taken a special interest in the performance of air/vapour barrier systems. One of the key program requirements is a tight, draft-free building envelope. Much effort has been put on reducing air leakage in homes.

Although this can be achieved with a variety of techniques, many R-2000 builders find the use of a poly vapour barrier to be the easiest, most effective technique for achieving airtightness.

Another method that is gaining recognition uses the airtight drywall approach (ADA). Both methods when combined with proper building practices have been successful in reducing envelope air leakage.

Polyethylene vapour barriers

Polyethylene is known to deteriorate when exposed to excessive heat or ultraviolet radiation from sunlight. Concern has been expressed that polyethylene air/vapour barriers degrade over time.

Examples of polyethylene degradation have been discovered occasionally, but usually this is only noted when a wall is opened. If it fails after the house is completed, you don't really know until the wall has been opened.

Other factors affecting the long term performance of polyethylene are its composition and production techniques. Poly specifically suited for the building industry is a low-profit item. Only recently has a product standard for polyethylene has been developed, but it only covers 6 mil poly.

Under the new CGSB standard, poly film that is manufactured for use as an air/vapour barrier must be:

1. stabilized against heat and ultraviolet light (sunlight);
2. packaged so that it is protected from direct exposure to sunlight;
3. made only from virgin resin;
4. of a minimum average thickness of 6 mil

Buchan, Lawton, Parent Ltd. analyzed available data on airtightness tests done on the same houses over a period of time. The object was to determine if the concern about polyethylene decay over time was justified.

Raw data was collected on 145 homes from a variety of sources. Data was used only if:

1. the fan tests were done on the same house by the same firm (to avoid any possible inconsistency in test methods);
2. the construction of the house was complete (if the tests were done before the house was completed, the difference in airtightness is not useful); and
3. the initial air change rate per hour (ACH) was less than 3.0 (if the leakage was greater the polyethylene was assumed not to be performing as an air barrier).

These houses considered included
- 34 Energy Efficient Homes in Ontario
- 15 homes in Sweden
- 5 homes in Montana
- 30 low energy homes in Saskatoon
- 22 R-2000 homes tested by Buchan, Lawton, Parent Ltd.
- 20 Flair EnerDemo Homes (including: 6 R-2000 Polyethylene and 14 R-2000 air tight drywall construction (ADA).

The data included houses which had been retested more than two times (as many as seven air tests were done on the 20 Flair homes within a two-year period).

The tests were done some time after construction was fully complete, in most cases more than three months after completion.

The 90 homes that met the criteria were separated into two groups: those with an initial air change rate of less than 1.5 ACH and those with an initial

ACH between 1.5 and 3.0. The initial ACH, the time in months between tests, and the difference in change between the first test and each subsequent test were looked at.

Homes were considered to have a significant loss of tightness if there was an increase in the air change rate of more than 0.3 ACH and if the change was more than a 20%.

Of the 42 homes with an initial ACH less than 1.5 only six homes had a significant loss of tightness under both criteria. Of the 48 homes with an initial ACH between 1.5 and 3.0, only three homes met both criteria. This indicates that there is only a minor average change in airtightness.

Overall, the data examined indicated relatively minor changes in average airtightness (decreases of well under 10%). A relatively small proportion of houses actually showed an increase in airtightness.

It is not clear from the report if an analysis was made of the poly material used in these various studies. This is a factor to consider, as there have been some higher quality, durable poly materials on the market, especially in Scandinavia and in the USA.

Analysis was done to determine if there was a common pattern to the changes in test results over time. A sudden increase between two tests with little change before and after that increase, would be an indication of catastrophic, probably physical, damage to the air barrier of the building. A gradual increase in the air change test results would be evidence of a gradual degradation of the air sealing characteristics. No common pattern was detected in the group of houses for which multiple test data was collected, making the analysis inconclusive.

There is no indication that significant problems exist that would necessitate a change to current building practices.

These observations do not indicate that polyethylene degrades when used as an air barrier for residential buildings. However, the lack of negative evidence does not prove conclusively that problems will not develop over a period of a decade or more.

FUNCTIONS OF AN EFFECTIVE AIR BARRIER

it must be:

- impermeable
- continuous
- flexible
- able to withstand any loads placed upon it.

The air barrier must be flexible enough to adjust to any structural movement without allowing openings that may form.

Polyethylene vapour barriers usually allow for some stretching and movement without the envelope being broken.

In the ADA, the joints must be made of elastic gaskets or flexible caulking to allow for movement. Each system has a limit on the extent of movement it can allow.

Comparison of Airtightness Retesting Results prepared by Buchan, Lawton, Parent Ltd. for Energy Mines and Resources. Copies of the report can be obtained from
EMR, Energy Publications,
460 O'Connor St.,
Ottawa, Ont. K1S 5H3

Letter to the Editor

Sir,

In the February-March issue (Solplan Review No. 25) you ran an article titled "WOOD-ELECTRIC HEATING SYSTEMS". The systems illustrated are not safe due to the fire danger and the possibility of asphyxiation of the building occupants from flue gas leakage. For that reason they are prohibited by the B.C. Building Code.

Home made solid fuel burning furnace add-ons are difficult to make safe and for the average home owner or installer just about impossible to verify as safe. In this day and age of ULC/CSA standards with testing laboratories and certification of heating systems using heat sensors and measuring spillage to construct a system like that illustrated in your article is foolish.

There are ways of safely combining wood heat and electric furnaces. The best way is with a certified wood furnace add-on. This appliance is installed after (downstream of) the electric furnace. This way the super heated air does not pass through the fan and plenum of the furnace. If installation and clearances are to the manufacturer's tested guidelines the owner can be assured that he or she has a safe heating system.

Another safe wood electric installation is with the electric furnace in the basement or crawlspace and the space heater (wood stove) on the main floor. The return air grill is located at ceiling height in an interior wall in the warmest area of the dwelling.

Convection combined with circulation and distribution using the furnace fan on low speed will give a uniform temperature throughout the home. As the space heater is located in the positive pressure zone the danger of spillage is removed (if the house is ventilated properly with combustion and/or make-up air). The fire danger is also eliminated as a capture hood is not used and the return air grill is located at least 60" away from the space heater. (Return air grills should not be used in an alcove that has a heater installation.)