KNAUF INSULATION
it's time to save energy

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Air Infiltration & the KISS™ System

EcoSeal™ & Knauf Insulation Glasswool Products

AN ECOSEAL WHITE PAPER

KNAUF INSULATION KISS & SEALING SYSTEM

A COMPONENT OF THE KISS™ SYSTEM

Air Infiltration & the KISS™ System

Most homes are ventilated by natural air leakage. This leakage may play an important role in determining the air quality of the home. However, uncontrolled air leakage can often carry a significant energy penalty due to excessively cold or warm and moist air and its impact on heating and cooling loads. Uncontrolled air leakage can also bring in excessively dusty or contaminated air depending on the surroundings for the home. Air leakage can account for as much as 40% of annual heating and cooling costs. Air leakage can also cause drafts within the living space or allow the ingress of excessive moisture into the building structure.

Air leaks into and out of buildings through penetrations of all types. Some are clearly visible, some are not. Some are intentional, like exhaust vents, some are not. Air leakage most often occurs at joints between building materials. Irregularities in the building's exterior, such a protrusions and penetrations, are often leakage points because they often involve multiple joints. These areas pose air sealing difficulties and deserve special attention whether the project is an energy retrofit or new construction.

In new construction, air leakage can be significantly reduced by the use of continuous air barriers, carefully installed and completely sealed on the exterior building shell. Most older homes do not have any air barrier installed. Testing that has shown that a very well installed exterior air barrier material is sufficient for achieving air tight homes in new construction. However, in today's construction market, this careful installation is very seldom achieved. Additionally, other building trades often make penetrations to the exterior shell that often negate even the most careful installations of exterior air barriers. Once the exterior barrier has been compromised, it is up to the individual components of the construction to offer air flow resistance against leakage. This resistance is typically measured using a constant air pressure, 50 Pascals (0.2" water column) to determine air flow in cubic feet per minute (cfm). The chart below is based on research conducted by the Canada Mortage Housing Corporation.

Air Leakage through Construction Materials

Material	Air Leakage (cfm/100 ft^2@ 50 Pascals)
⅝" oriented strand board	0.09
½" drywall	0.26
4-mil air barrier paper	0.26
⅛" hardboard	0.37
1" EPS (dense)	1.50
15# perforated asphalt felt	5.30
Standard concrete felt	7.90
1" EPS (light)	170
⅝" tongue and groove boards	300
6" glasswool batt	490
3" vermiculite	930

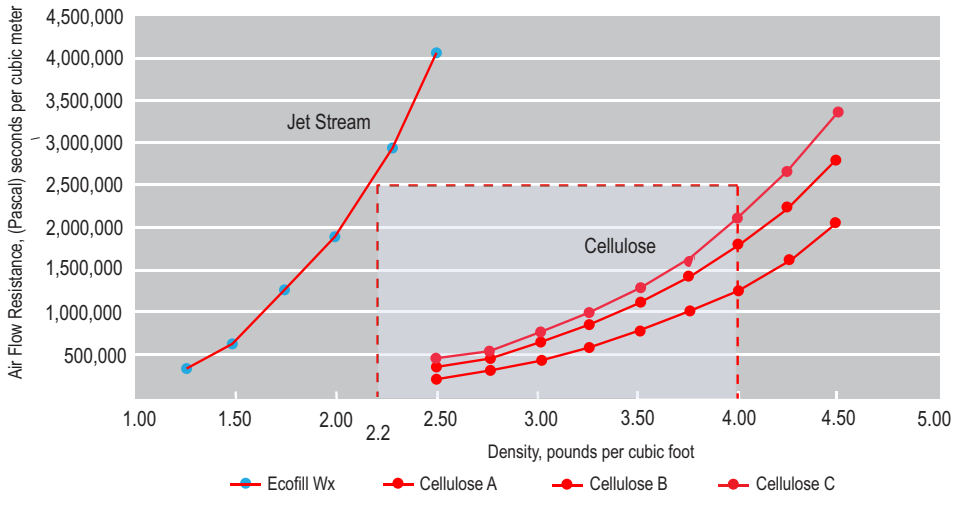
With reference to the chart above, materials with air leakage characteristics greater than 2 would not be considered effective air barriers. If one were to use the example of a 2048 square foot home with 8 foot ceiling (32' x 64' foot print), the volume within the conditioned space would be 16,384 cubic feet. If the home were sheathed with wood siding over 65% of its surface area (~1000 sf) and there was no other air barrier, the total leakage through the tongue and groove would be 1000 x 300 = 300,000 cfm or nearly 1100 air changes per hour at 50 Pascals! With a 4-mil air barrier paper and the same assumptions, the infiltration rate through the paper barrier would be ~1 air change per hour at 50 Pascals. There are some materials that test higher than others for absolute air flow resistance, but the differences between effective air barriers are generally insignificant when compared to other building elements such as doors and windows, chimneys and vents, clothes dryers and the need for makeup ventilation. When considering construction materials and techniques that would minimize uncontrolled leakage, it's also important to remember that some level of fresh air is required to maintain acceptable indoor air quality. Small uncontrolled leakage points are often difficult to find and generally not cost justified in the larger scope of an air sealing project.

When providing energy efficient retrofits to existing buildings, it is generally neither feasible nor practical to install new exterior air infiltration barrier materials. The practitioner will seal the obvious and accessible penetrations in the attic and floors and then treat the less accessible leaks in the walls with a variety of methods. It is very common to let densely packed insulation provide both the thermal resistance as well as the air infiltration resistance.
In energy retrofits of walls, dense packed cellulose with density of up to 4 pounds per cubic foot (pcf) has gained favor because it is perceived to provide superior air flow resistance when blown into walls. Many weatherization traditionalists believe that dense packed cellulose is the best solution to insulate and improve air infiltration resistance. On the contrary, densely packed glass fiber can provide superior air flow resistance with approximately half the weight.

Cellulose and fiber glass are both fibrous materials. The ability of fibrous materials to resist air flow is directly related to the tortuosity of the path air must travel to pass through the fibrous matrix. Tortuosity is directly related to fiber diameter and number of fibers per given volume of insulation.The average fiber diameter of fibrous glass is many times smaller than the average diameter of random and coarse cellulosic fiber. This leads to a significantly more tortuous path for air flow at roughly equivalent installed densities. Knauf Insulation had tests conducted by Intertek Laboratories to measure the air flow resistance of the Knauf Insulation retrofit and weatherization product, EcoFill Wx, over a range of densities between 1.8 and 2.5 pcf. The typical density attained during sidewall retrofits installations of EcoFill Wx is 2.2 pcf. We also had 3 national brands of cellulose insulation tested over a range of installed densities ranging from 3.3 to 4.5 pcf.

The following chart summarizes these results.

Air Infiltration: Knauf Insulation Premium Blowing Wool vs. Cellulose



The chart graphically illustrates that EcoFill Wx, when installed at a typical retrofit wall insulation density of 2.2 pcf, has as much air flow resistance as dense packed cellulose of densities ranging from 4.2 to 4.7 pcf. Many of the national weatherization training organizations state that cellulose is an effective barrier at installed densities of 3.5 pcf or greater. This testing shows that EcoFill Wx is approximately 2.5 times more effective than cellulose at this minimum performance level. The cellulose manufacturers continue to compare their dense pack against fiber glass batts for retrofit. This is clearly a misleading comparison when considering sidewalls.

Knauf Insulation (KI) recognizes that there is still a significant need for effective air sealing in both old and new construction. We also recognize that dense packed fiber glass by itself may not be sufficiently effective as a leakage barrier for highly efficient new construction, or cost effective as an air barrier for all retrofit applications. For this reason, KI has developed a sealant and insulation package known as KISS, which provides a very cost effective means to achieve highly energy efficient building envelope constructions. KISS combines a water based elastomeric sealant known as EcoSeal with our environmentally friendly EcoBatts™ or our premium blowing wool insulations, JetStream and EcoFill Wx.

KI had the KISS system tested for air sealing characteristics at the NAHB Research Center. Test walls were constructed using 2x4 framing at 16" on centers that measured 8' high by 10' long. There was a single bottom plate and a double top plate in the assemblies. One interior electrical box was included and the wiring was run through each stud for the entire length of the wall at the height of the box. The wall was insulated with inset stapled R-13 fiber glass kraft faced batt insulation. The interior side was covered with ½" drywall and the seams were taped with one coat of tape joint compound. The exterior was sheathed with 7/16" OSB with a horizontal gap running the length of the wall. Tests were run with a base wall containing neither air barrier or sealant, with air barrier taped and untaped, and with air barrier and Ecoseal. All tests were conducted per ASTM E283 and the results can be summarized in the table below.

Leakage Testing at 50 Pascals—
CFM per 80 Square Feet of Wall

Construction	No EcoSeal	EcoSeal on Horizontal Seams	EcoSeal applied in "Picture Frame"
Base Wall	9.73 CFM	5.17 CFM	1.20 CFM
With House Wrap	1.78 CFM	2.17 CFM	0.60 CFM
House Wrap Taped	1.22 CFM	0.85 CFM	0.18 CFM

These results show that a "picture frame" application of EcoSeal without house wrap can reduce air leakage to the same level as taped house wrap. Using EcoSeal in combination with taped house wrap resulted in a leakage reduction of 98% as compare to the unsealed base wall case. A leakage of 0.18 cfm over 80 square feet yields an air leakage factor of 0.00225 cfm/sf. It is important to note that this was a wall construction with no windows or other typical construction elements but it does dramatically illustrate the ability of EcoSeal to yield very air tight structures.

THE IMPACT OF OTHER BUILDING ELEMENTS ON AIR INFILTRATION

Consider the following example:

Good quality windows could have an air leakage of 0.25 cfm/ square foot of window area. Doors with weatherstripping will typically leak 0.18 cfm/sf. If you assume a fenestration percentage of 20% and a door area of 10% for a wall, the resultants leakage would be: .00225 * .7 = 0.0016 cfm for the wall, .25 x .2 = 0.05 cfm for the windows and .1 x .18 = 0.018 cfm for the door. Therefore, the leakage contribution of the wall with Ecoseal is 0.0016/ (0.0016+.05+.018) = 0.023.

This means that the sealed wall is only contributing 2.3% of the total leakage of this wall. In reality, walls and ceilings ususally have many other penetrations and construction complexities. Most of these can also be sealed effectively with EcoSeal

These results show that the combination of EcoSeal with Knauf Insulation fiber glass products can provide air leakage numbers essentially the same as those achieved by spray applied foams. The advantage of the KISS system is that it can provide higher R-values than either light density foam or cellulose and outstanding leakage resistance. When combined with KI fiber glass insulations, it offers a very cost competitive solution for energy efficiency.

It is important to account for the indoor air quality affects that might come with tight envelope sealing. Traditionally, U.S. homes have relied on natural air leakage to provide sufficient fresh air to dilute pollutants within the living space. Older homes have been measured to have typical ventilation rates of 0.5 to 1.0 air changes per hour (ach); some homes have been measured as high as 2 ach. Tightly sealed homes may achieve leak rates as low as 0.1 air changes per hour, with 0.25 ach being typical. The proper use of EcoSeal can easily provide structures with air infiltration rates of 0.25 ach or less. While this can represent significant energy cost savings to the homeowner, the lack of fresh air could cause health issues to the occupants. For these tightly sealed homes, mechanical ventilation must be designed into the home to introduce fresh air in the most energy efficient manner. ASHRAE Standard 62.2 and the BPI Standards both provide guidance on minimum fresh air requirements for residential buildings. **Knauf Insulation highly recommends that these Standards be followed whenever energy efficient new home designs or existing home retrofits are contemplated.**

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