High R-Value Does Not Always Mean High Performance

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Ever since the energy crisis of the 70s we have been told how important it is to insulate our homes. Today you couldn’t sell a home without insulation. But installing the right amount of insulation does not mean the home is well insulated. How the insulation is installed can have a bigger impact on energy use and comfort than the amount of insulation, even if it is the right amount. Improper installation of insulation can dramatically impact its effectiveness, in many cases making it completely ineffective.

For a home buyer this means increased utility bills, but for a builder this can greatly increase the potential for comfort complaints and unhappy buyers. In my work in residential energy efficiency, the biggest issue I’ve seen with insulation performance is misalignment.

What is misalignment?

Homes are built with two main structural elements that impact their energy use; an air barrier and a thermal barrier. The air barrier is designed to keep inside air in and outside air out. In the majority of homes drywall is the most common building material used as an air barrier. The thermal barrier (insulation) is designed to keep heat in or out of a home.

Most of the insulation (fiberglass, cellulose and mineral wool) used in today’s home does not stop air flow. Air, if given the chance, will flow right through the insulation. Because of this, the air barrier and thermal barrier must be aligned (touch), if not, hot air rising or cold air falling will pass through or around the insulation, greatly reducing its effectiveness. Even a small space will allow air to begin to circulate as it is heated or cooled. If we are talking about insulation located in the attic, hot attic air at 140 degrees or more can get between the drywall and insulation. In the summer this can cause the inside surface temperature of the drywall to be over 100 degrees. This can make for very unhappy home owners.

This is even more important in today’s homes because of the complexity of the ceiling and wall. Arches, soffits, chases and other design features have created a very uneven air barrier (drywall plane) which in many instances is difficult if not impossible to insulate. Just walk through a home during framing and imagine where the drywall will go and where the insulation will go. What are the chances of them touching?

What follows are a series of photos and infrared thermography that document misaligned insulation. The infrared thermography “see” the surface temperature of a material. Darker areas are cooler than white areas. These images are inside of a Phoenix home in the summer, so dark is good (low heat flow) and white is bad (high heat flow).
When the drywall is installed on this knee wall there will be a five and a half inch space between the drywall and R-30 batt. In the summer the air between the drywall and insulation will be cooled by the air conditioning and fall out of the space. Hot air from the attic will replace the cooled air and the process will repeat itself. In the winter the hot air will rise and escape, being replace by cold attic air.

The result in the summer is a hot wall, as this infrared shows. Note that the studs, at about an R-4 (wood has an R-value of about 1 per inch) are darker, slowing heat flow better than the R-30 batts. The R-30 batt is letting more heat in than the R-4 stud. The builder installed an R-30 but got something less than an R-4.
Here is an example of misalignment in a ceiling. In this case the batt is draped over the ceiling truss, creating a three and a half inch space between the drywall and insulation.

**Insulation draped on joists**

Just a slight misalignment
In this infrared, the batt is draped over the truss of a sloped ceiling causing misalignment between the dry wall and insulation. Because of the misalignment the R-30 batts again are being outperformed by an R-4 piece of wood.

Unfortunately it is not just an issue of aligning the insulation and air barrier. There are many design features in home where there is not an air barrier, of it would be next to impossible (or very costly) to insulate the air barrier. Examples of this include soffits, chases, arches, basically any design feature where the plane of the air barrier (dry wall) is broken or uneven.
Looking at this attic insulation you can not see any problems. But notice in the upper right hand corner of the picture, there is a flex duct going through the insulation into a chase. The question - Is the chase capped so the insulation is touching an air barrier?

The answer - No

This chase is directly connected to the attic. It will also connect any other building components that are connected to the chase to the attic.
The image on the left is what you see from the inside looking at a duct chase. The image on the right is the infrared of the chase; it is uncapped and allowing hot air to migrate through the insulation, heating up the dry wall (and house).

Shafts and chases for ducts, vents, pumping and other utilities need to be capped with a ridged air barrier. Using batt insulation does not work!
Ensuring that insulation actually insulates

The key to insulation performance is having everyone in the process understand the importance of aligning the insulation with the air barrier.

The designer should clearly state where the air and thermal barriers are to be installed. In those areas where it is impractical for the drywall to serve as an air barrier, such as over arches, soffits and other irregularities in the drywall surface, a ridged material should be called for to cap or seal these areas. Put these details in the plans so there are no questions. Here is an example of a drop ceiling detail.

The builder needs to implement a process that will verify that plans and installation specifications are followed. For example, a check list of critical areas could be used.


The framer needs to establish air barriers in all locations where the drywall will be ineffective as an air barrier. This will provide a continuous air barrier that can be easily insulated.
Here is an example of a ridged air barrier installed over a duct chase. When the dry wall is installed, there will be a continuous, even air barrier for the insulation to be installed onto.

It's also critical that other trades do not destroy the air barrier/insulation alignment.

Here is an example of where the wiring will hold the batt away from the dry wall. The batt should have been split and install so the wire has insulation on both sides. This also insures the batt is not compressed.
It’s also critical that other trades do not destroy the air barrier. Simple rule for all trades, if you create a hole, you must seal the hole.

The insulator needs to install the insulation in 100 percent contact with the air barrier or so that when the drywall is installed they will touch. The insulation also needs to be continuous, with no gaps, no voids, or no compression.

The drywall contractor should be able to simply install the drywall as designed.
Insulation that insulates

When insulation touches an air barrier, it insulates. The images above were taken on the same day, in the same subdivision. The infrared on the left was taken of a home built prior to changes in framing to address alignment. The image on the right is of a home (same model, same wall) built after changes in framing were instituted by the builder that ensured air barrier and thermal barrier alignment. In July of 2006, the EPA Energy Star Homes Program put new guidelines into effect that addresses insulation and air barriers. The Thermal Bypass Inspection Check List requires visual inspection of framing areas where air barriers are commonly missed and inspection of insulation to ensure proper alignment with air barriers, thus serving as an extra check that the air and thermal barriers are continuous and complete.

What can a builder do?

Builders can simply demand that the insulation is installed with no voids, no gaps, no compression, no wind intrusion and no misalignment. Make this part of your specification and make sure these guidelines are followed.

Additional information: