Insulation Inspections for Home Energy Ratings

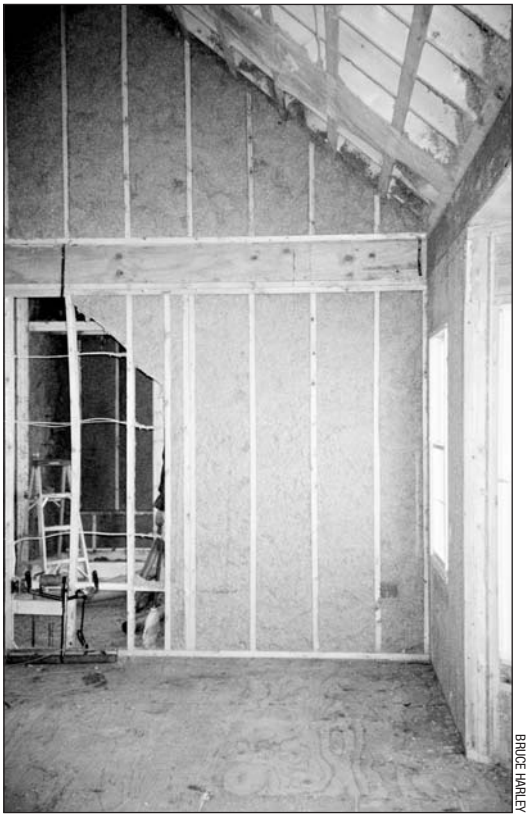
Assessing insulation gaps, compression, and incomplete fill provides a way to measure installation effectiveness.

by Bruce Harley

Poorly installed insulation can significantly impair the thermal performance of building components. We've all seen thermography images of insulated surfaces that clearly show that the insulation is inadequate. We've all seen batts that are placed carelessly, loose-fill insulation that looks like the Rocky Mountains, or exterior rigid foam installed not just with gaps between the sheets, but barely even touching the rest of the wall. Quantitative research generally supports the idea that insulation must be installed carefully to maintain its rated performance, and energy codes require proper installation. A statement such as "All insulation materials… shall be installed in accordance with manufacturer's instructions" is found in every published edition of the Model Energy Code (MEC) and the International Energy Conservation Code (IECC).

Manufacturer's instructions aren't always what you get in the field. Most installation instructions require fluffing insulation to the proper thickness, covering continuously, filling cavities completely, and fitting products around all obstructions, such as wiring, plumbing, and framing. However, insulation is difficult to install perfectly—and in most markets, with installers paid by the ft^2, there's little incentive to get the details right.

With the popularity of the Energy Star Homes program, HERS ratings are widely used to assess energy efficiency in new construction. How does a HERS rater deal with the insulation situation?



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This sprayed cellulose job is a Grade I for sure—filling all cavities completely, firm to the touch, and not slumping away from the top plates.

Unfortunately, the current Residential Energy Services Network (RESNET) standards do not address insulation inspections. Some raters have historically done inspections only at the completion of a project; how can they assess the insulation once the drywall is in place? Furthermore, raters who diligently enforce the proper installation of insulation products may be at a competitive disadvantage relative to raters who are not so picky. HERS ratings measure the estimated performance of a home relative to a code baseline—but the language in the code does not define performance of improperly installed insulation. Hence, insulation cannot be assigned an effective overall R-value. To address these issues, the RESNET Standards Amendments Drafting Committee has proposed an insulation inspection amendment to the RESNET standards. This amendment (along with other technical amendments) will be considered for adoption by the RESNET board, and if accepted, will become effective on January 1, 2006. (See "Lights, Appliances, and Sunshine: A New HERS?" *HE* Nov/Dec '02, p. 16 on lighting and appliances in HERS.)

How It Works

When the RESNET drafting committee considered the concept of field assessment for insulation quality, two major concerns were addressed. First, clear guidance to field inspectors was a must; to ensure consistency, there needed to be relatively little room for differences in individual judgment. Second, there needed to be a legitimate, defensible mechanism to handle software simulation of varying performance levels, and that mechanism had to be connected to the visual assessment of the installation. What we settled on was an inspection regime that defines three levels of installation quality, referred to as Grade I, Grade II, and Grade III. For each level, the protocol defines a threshold, or boundary condition, that

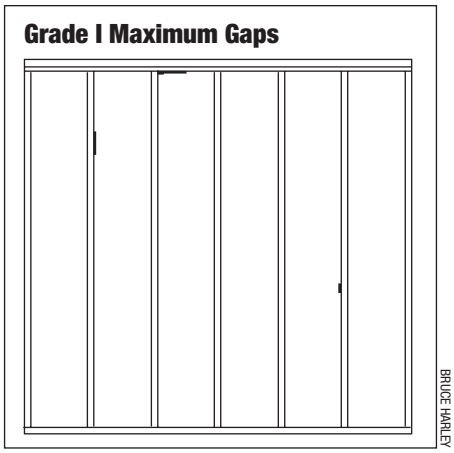

Figure 1. Occasional very small gaps are acceptable for "Grade I."

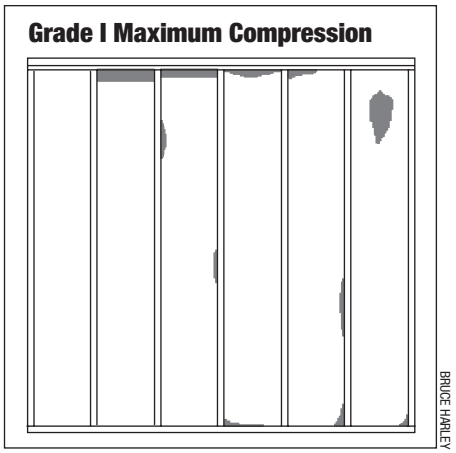

Figure 2. The gray shading shows insulation compression or incomplete fill of approximately 2%.

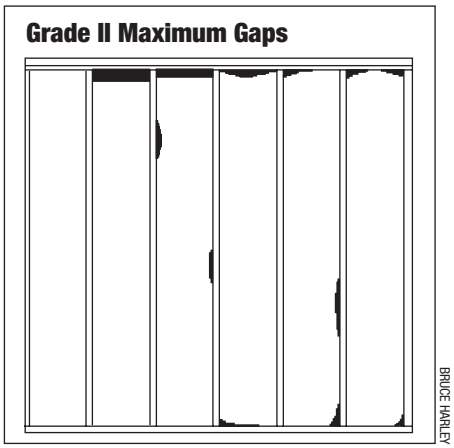

Figure 3. The black shading represents insulation gaps of approximately 2%.

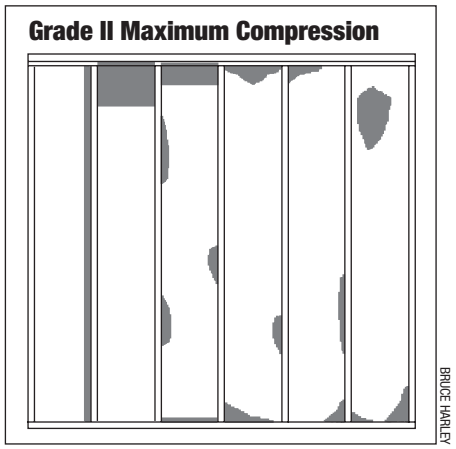

Figure 4. The gray shading represents insulation compression or incomplete fill of approximately 10%.

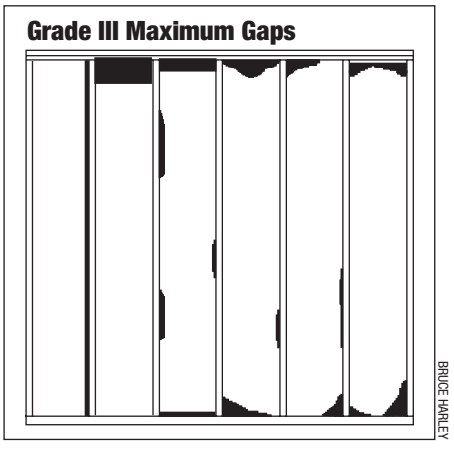

Figure 5. The black shading represents insulation gaps of approximately 5%.

the installation must meet to be assigned to that level—essentially the worst case allowed for that grade. And at each level, the performance qualities defined in software correspond with that level's boundary condition. (For readers who are familiar with energy codes, this is similar to the concept used in the prescriptive tables for compliance with MEC 1995 and IECC 2000. If a home has glazing area within a range—such as 10%–13%—of wall area, the code requirements for the envelope are based on the worst case within that range, or 13%.)

Insulation Inspection Procedures

In order to qualify for a Grade I rating, insulation must be installed according to the manufacturer's instructions and/or industry standards, where available. It must fill each cavity side to side and top to bottom, with no substantial gaps or voids around obstructions (that is, blocking or bridging), and it must be split, or fitted tightly, around wiring and other services in the cavity. In general, no exterior sheathing should be visible through gaps in the material (see Figure 1). Occasional very small gaps are acceptable for Grade I.

Compression or incomplete fill amounting to 2% or less of the surface area of insulation is acceptable for Grade 1, if the compression or missing fill spaces are less than 30% of the intended fill thickness (that is, 70% or more of the intended insulation thickness is present) (see Figure 2).

Note that the condition for compression or incomplete fill is different from the condition for overall compression. For example, if R-19 insulation rated at 6 1/2 inches thickness is installed in a 2 x 6 stud bay—which is 5 1/2 inches wide—the R-value would typically be R-17, depending on the manufacturer. In that case, one would begin with the R-17 value, and then apply the inspection grade. Of course, it is already a requirement that software account for framing thickness and spacing, and interior and exterior sheathing materials, in addition to the cavity fill insulation value.

A Grade II rating represents moderate to frequent defects: gaps around wiring, electrical outlets, plumbing, other intrusions; rounded edges or "shoulders," larger gaps, or more significant compression (see Figure 3). No more than 2% of the surface area of insulation missing is acceptable for Grade II. No more than 10% of the surface area of insulation compressed or incompletely filled by 30% or less of the intended thickness is acceptable for Grade II (see Figure 4).

A Grade III rating applies to any installation that is worse than Grade II; in other words, gaps and voids amounting to more than 2% of the surface area, or compression or incomplete fill in more than 10% of the surface area of insulation,

Table. Summary of Insulation Standards

Criteria	Grade I	Grade II	Grade III
Gaps in insulation coverage:	Minimal, occasional	Up to 2%	More than 2%, up to 5%
Compression or incomplete fill (up to 30% of intended thickness missing):	Up to 2%	More than 2%, up to 10%	More than 10%
Walls, rim or band joist between floors:	Enclosed on all 6 sides	Enclosed on all 6 sides	Open on one side
	In contact with interior or exterior sheathing	In contact with interior or exterior sheathing	"Floating" in the middle of the cavity
Ceilings:	In contact with interior sheathing (drywall)		
	Requires eave baffles		
Floors:	In contact with interior sheathing (subfloor)		
Floors over outdoor air or vented:	Enclosed on all 6 sides		

or if compressed or incompletely filled spaces are 30% or more of the intended fill thickness. However, there is still a boundary condition for Grade III (see Figure 5). No more than 5% of the surface area of insulation missing is acceptable for Grade III.

For an installation that is worse than Grade III, the procedure specifies that the inspector must measure the insulated areas separately from the uninsulated areas and input them separately in software. For example, if a wall area of 100 ft^2 has 10 ft^2 with no insulation, the 10 ft^2 must be assigned as an uninsulated cavity wall.

Other Requirements

The procedure expressly forbids averaging R-values over area, which is commonly done, but which is a technical no-no. It also calls out specific requirements for calculating performance of steel-framed walls.

There are some additional conditions and limits for wall, ceiling, and floor insulation. To attain a rating of Grade I or Grade II, wall insulation must be enclosed on all six sides. Sheathing wrap is acceptable, but walls that are open on one side to an attic, crawlspace, or other unconditioned or vented area will be considered to be Grade III. Also, Grade I or II wall insulation must be in substantial contact with the sheathing material on at least one side of the cavity—whether interior (drywall) or exterior. Rim and band joists follow the same rules as walls.

For ceilings to receive a Grade I rating, the insulation must be in complete contact with the surface it is intended to insulate, and eave baffles must be installed to prevent windwashing of the insulation by vent air from the soffits. Ceiling insulation need not be enclosed on six sides. Further, for ceilings, rating inspectors need to note whether the framing is covered by insulation or is exposed, and how much insulation covers the framing. This assessment must be included in the simulation model, with cavity insulation treated separately from continuous insulation that covers the framing.

For floors to obtain a Grade I rating, the insulation must be in complete contact with the surface it is intended to insulate. Floor insulation need not be enclosed on six sides if the floor is exposed to an enclosed, unconditioned basement. If the floor is exposed to a vented crawlspace, is cantilevered, or is otherwise exposed to the outdoors, it must be sheathed to obtain Grade I. (See Table for a summary of the requirements.)

Are Inspections Required?

Some raters and rating providers are concerned that a long-established business model that does not include predrywall inspections will be compromised by an inspection requirement—will they be able to provide a rating at a price the market will bear? Does this proposal require insulation to be inspected for all HERS ratings? The answer is yes and no. Yes—to take full credit for thermal performance of a properly installed product, according to manufacturer's published R-value, insulation must be inspected prior to installation of drywall. But no—the standards will not require an inspection to provide a legitimate HERS rating, much as the standards currently do not require direct testing of building and duct leakage with a blower door and duct tester. HERS ratings encourage testing, but if raters wish to rate a home without testing, they can accept conservative performance defaults for items that aren't inspected. This proposal handles insulation the same way. If inspection is conducted, the insulation performance is handled according to the inspection criteria. If there is no inspection, the performance used in software is defaulted in software to a level that is the equivalent of a Grade III installation. The proposal also provides an exception for modular and manufactured housing that has in-plant third-party inspections, and for construction systems (such as structural insulated panels or insulated concrete forms) that have an R-value defined by the structural materials themselves, rather than by field-installed insulation.

Raters have expressed concern about the extra burden of calculating the various performance levels. It is generally agreed among the drafting committee (which includes two software providers) that the rating system will be handled in software. Consider a typical example: a 2 x 6 wall with R-19 insulation rated at 6 1/2 inches, that gets a rating of Grade II at the rough inspection. The HERS rater would assign the assembly an R-17 wall, with appropriate on-center stud spacing and interior and exterior sheathings, and would choose Grade II from a set of radio buttons. The software would do the rest.

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This rigid foam might be on the edge between Grade I and Grade II; notice that the mason had inserted a small piece of foam to fill part of a larger gap (lower center). There are more gaps and skewed pieces nearby at the exterior corners (outside the photo), so this ends up as a Grade II.

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The 8ft by 10ft raised area shown is a Grade III installation at best; 10% of the area clearly is short of the indicated thickness by 30% or more.

More Work to Be Done

This proposal, while it goes a long way toward addressing varying installation quality, does not address every pitfall in the insulation field—but it is a beginning. First of all, it is intended to be used when it is possible to inspect insulation as installed, that is, in new construction. In other words, it does not apply to insulation that is blown into walls or cathedral ceiling cavities of existing homes. (Scheduling problems in new construction do not qualify as an exemption.) Many types of cavity fill or attic loose-fill insulation are very sensitive to density, and some observers suggested that we incorporate a density test. However, density tests have vagaries of their own. For the time being, a rater who is concerned about fill densities would do best to rely on the installer's R-value certification (required by the Federal Trade Commission R-value rule), and back it up with a bag count to verify the amount of material.

Another option considered by the drafting committee was an allowance for infrared imaging that could handle both retrofits in existing homes, and post-completion inspections for new construction. Unfortunately, the problems posed by thermography include not only how to interpret the results, but also how to define acceptable conditions (equipment resolution, indoor and outdoor temperature conditions) to ensure consistency of application. The committee agreed that for the current round of amendments to the HERS standards, this proposal would suffice, and that it provides a sound and viable means to address a range of insulation conditions commonly found in the field.

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For more information:

The Mortgage Industry National Home Energy Rating Standards is available at www.natresnet.org/accred/amended.htm.

The proposed amendments to the standards can be found at www.natresnet.org/amend/default.htm.