Insulation That Works

With closed-cell spray foam, the benefits go way beyond R-value

by Steve Easley

These days, it's not an exaggeration to say that almost all homeowners expect their homes to be durable, energy efficient, safe, and comfortable. But this is especially true in coastal markets that cater to high-end clients who demand supreme quality and impeccable performance from their homes. Even in today's markets, which are euphemistically described as "relaxing," there seems to be no shortage of wealthy home buyers snapping up second-home properties along the coveted coast. If you build in this market, it's this kind of discriminating home buyer who will most expect you to get things right.

In more than 25 years of consulting with builders on ways to reduce callbacks, I've spent most of my time solving problems related to heat and moisture transfer through buildings, because this is often where builders — even very good builders who deliver well-appointed homes to the coastal elite — get things wrong. Most of the serious (read "expensive") performance failures are moisture related, and a good number of these are closely tied to the thermal performance of the home. Yet I am surprised how often the insulation is installed without much thought or understanding about how it works. Consequently, very little attention gets paid to the details that really matter. Typically, fiberglass — selected as the least expensive option up front — is jammed in the walls and stuffed around electrical wires, plumbing pipes, and HVAC ducts, then covered up as soon as the municipality allows. The result is gaps, compression, and hollow voids that com-

Batt insulation works best when it is fully lofted, not jammed into the tight spaces (left). Compression of the batt reduces the number of air pockets that provide the material's insulation value. It also leaves a hollow between the insulation and the drywall, creating areas where air can circulate. These voids can siphon off energy and may create conditions for condensation and moisture problems.

promise occupant comfort and increase the building's energy loads. A sloppy insulation job can also lead to moisture problems by creating thermal conditions in walls and ceilings that promote condensation, wetting, mold growth, and rot.

BRIGHT STAR

The updated Energy Star label for homes provides a quality standard that can guide builders away from these problems. New program requirements have raised the level of quality in the program, making it a label that savvy home buyers will more likely be looking for. As of January 1, 2007, a home that qualifies for an Energy Star label must pass a "thermal bypass inspection": a rigorous assessment of a home's air barrier. The bypass inspection requires builders to follow the EPA's Thermal Bypass Inspection Checklist — a 25-point list of details aimed at stopping the movement of heat around or through the insulation. Thermal bypasses — the defects that most commonly reduce the energy performance and comfort of homes — typically result from missing or compressed insulation, missing air barriers, and gaps between the air barrier and the insulation.

In my opinion, this checklist is one of the best guidelines to come out of the

ENERGY STAR Qualified Homes
Thermal Bypass Inspection Checklist

Home Address:_____ City:_____ State:_____

Thermal Bypass	Inspection Guidelines	Corrections Needed	Builder Verified	Rater Verified	N/A
1. Overall Air Barrier and Thermal Barrier Alignment	**Requirements:** Insulation shall be installed in full contact with sealed interior and exterior air barrier except for alternate to interior air barrier under item no. 2 *(Walls Adjoining Exterior Walls or Unconditioned Spaces)*				
	All Climate Zones:				
	1.1 Overall Alignment Throughout Home	☐	☐	☐	☐
	1.2 Garage Band Joist Air Barrier (at bays adjoining conditioned space)	☐	☐	☐	☐
	1.3 Attic Eave Baffles Where Vents/Leakage Exist	☐	☐	☐	☐
	Only at Climate Zones 4 and Higher:				
	1.4 Slab-edge Insulation (A maximum of 25% of the slab edge may be uninsulated in Climate Zones 4 and 5.)	☐	☐	☐	☐
	Best Practices Encouraged, Not Req'd.:				
	1.5 Air Barrier At All Band Joists (Climate Zones 4 and higher)	☐	☐	☐	☐
	1.6 Minimize Thermal Bridging (e.g., OVE framing, SIPs, ICFs)	☐	☐	☐	☐
2. Walls Adjoining Exterior Walls or Unconditioned Spaces	**Requirements:** • Fully insulated wall aligned with air barrier at both interior and exterior, **OR** • Alternate for **Climate Zones 1 thru 3**, sealed exterior air barrier aligned with RESNET Grade 1 insulation fully supported • Continuous top and bottom plates or sealed blocking				
	2.1 Wall Behind Shower/Tub	☐	☐	☐	☐
	2.2 Wall Behind Fireplace	☐	☐	☐	☐
	2.3 Insulated Attic Slopes/Walls	☐	☐	☐	☐
	2.4 Attic Knee Walls	☐	☐	☐	☐
	2.5 Skylight Shaft Walls	☐	☐	☐	☐
	2.6 Wall Adjoining Porch Roof	☐	☐	☐	☐
	2.7 Staircase Walls	☐	☐	☐	☐
	2.8 Double Walls	☐	☐	☐	☐
3. Floors between Conditioned and Exterior Spaces	**Requirements:** • Air barrier is installed at any exposed insulation edges • Insulation is installed to maintain permanent contact w/ sub-floor above • **Optional until July 1, 2008**, insulation is installed to maintain permanent contact with air barrier below				
	3.1 Insulated Floor Above Garage	☐	☐	☐	☐
	3.2 Cantilevered Floor	☐	☐	☐	☐
4. Shafts	**Requirements:** Openings to unconditioned space are fully sealed with solid blocking or flashing and any remaining gaps are sealed with caulk or foam (provide fire-rated collars and caulking where required)				
	4.1 Duct Shaft	☐	☐	☐	☐
	4.2 Piping Shaft/Penetrations	☐	☐	☐	☐
	4.3 Flue Shaft	☐	☐	☐	☐
5. Attic/ Ceiling Interface	**Requirements:** • All attic penetrations and dropped ceilings include a full interior air barrier aligned with insulation with any gaps fully sealed with caulk, foam or tape • Movable insulation fits snugly in opening and air barrier is fully gasketed				
	5.1 Attic Access Panel (fully gasketed and insulated)	☐	☐	☐	☐
	5.2 Attic Drop-down Stair (fully gasketed and insulated)	☐	☐	☐	☐
	5.3 Dropped Ceiling/Soffit (full air barrier aligned with insulation)	☐	☐	☐	☐
	5.4 Recessed Lighting Fixtures (ICAT labeled and sealed to drywall)	☐	☐	☐	☐
	5.5 Whole-house Fan (insulated cover gasketed to the opening)	☐	☐	☐	☐
6. Common Walls Between Dwelling Units	**Requirements:** Gap btwn drywall shaft wall (common wall) and structural framing btwn units is sealed at all exterior boundary conditions				
	6.1 Common Wall Between Dwelling Units	☐	☐	☐	☐

Rater Inspection Date: _____ Builder Inspection Date: _____

Home Energy Rating Provider: _____ Builder Company Name: _____

Home Energy Rater Company Name: _____ Builder Division Name: _____

Home Energy Rater Signature: _____ Builder Employee Signature: _____

The Energy Star Thermal Bypass Inspection Checklist must be completed by a certified home energy rater. However, in order for a home to qualify for the Energy Star label, up to six items may be verified by the builder to minimize required field trips by the rater.

Insulation That Works

Living Spaces Over Garages

Living spaces over garages create conditions that demand careful attention to insulating the floor. Yet it is difficult to support the insulation in this cavity, and oftentimes the insulation falls onto the garage ceiling. This separation between the insulation and the living space floor creates a thermal bypass that compromises the value of the insulation. Air easily infiltrates in at the band-joist area over the top of the insulation, which scavenges away heat. This often freezes plumbing pipes, creates cold floors, and can lead to major mold and water damage. Builders often try to solve the problem by supplying forced-air heat near the plumbing, but this only succeeds in pressurizing the space with warm, humid air. As this air exfiltrates through the exterior cracks, it can condense and lead to even worse moisture and mold problems at the band-joist areas.

The issues are easily solved with ccSPF, which sticks to the bottom of the subfloor so insulation and air barrier are always in contact. The foam also stops air infiltration. It is a good idea to wrap any plumbing with a thin layer of fiberglass insulation before spraying foam over it to make servicing the plumbing easier.

EPA's Energy Star program, and I think it substantially raises the bar for thermal and moisture performance of building envelopes. Of particular value to builders, the 86-page *Thermal Bypass Checklist Guide* (available free online at www.energystar.gov; search "Thermal Bypass Guide") provides a very practical and comprehensive look at reducing air infiltration. It should be required reading for anyone who's serious about building a quality home in any climate, but especially in demanding coastal climes.

AN INSULATION FOR ALL REASONS

I've included in this article a short catalog of some of the problem areas addressed on the Thermal Bypass Inspection Checklist that I find are frequently missed.

What stands out about all of these problem points is that they can be difficult to get right with inexpensive fiberglass insulation unless a builder is working with an experienced and service-minded insulation crew. However, these problems are easily avoided when using closed-cell spray foam (ccSPF) insulation. This alone provides a strong argument for always using ccSPF, but it's certainly not the only reason.

There are many reasons why ccSPF makes particularly good sense in a coastal home:

- It has a high R-value of 6.5 to 7 per inch.
- It absorbs a negligible amount of water. It can even be used as an effective secondary rain barrier and is the only FEMA-approved insulation for flood-resistant construction.
- It does a good job of controlling diffusion.
- It has good air barrier qualities to reduce airflow into and out of wall cavities.
- It expands to fill voids in hard-to-insulate areas.
- It provides some structural integrity to the frame (see "The Structural Properties of Foam," page 26).

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Attic Knee Walls

These are areas where the insulation on the back side of unsheathed walls is exposed to outdoor temperatures and airflow. They are often adjacent to ventilated attic areas. The Energy Star Thermal Bypass Inspection Checklist requires that an air barrier be placed on all sides of the insulation. This means that the back sides of knee walls need to be sheathed and sealed. Thin-profile cardboard sheathing with ccSPF works well here. Since ccSPF is air impermeable, the insulation does not have to fill the entire cavity, and it meets the air barrier requirement. Some codes require R-19 insulation, which is difficult to do in a 3½-inch space with batt insulation, but 2 inches of ccSPF provides about R-19.5.

Sloping Roof Areas

The sloping areas in a cathedral ceiling can be the sites for significant thermal bypasses. These areas are not only difficult to insulate but are difficult to ventilate. Yet ccSPF solves both problems. Placing ccSPF directly on the underside of the roof deck also creates a secondary rain barrier, and because of ccSPF's high R-value and low permeability, moisture is not likely to condense on its surface, eliminating the need for cavity ventilation.

Band-Joist Areas

The band-joist area is typically a major site for air infiltration. These areas are usually very poorly insulated, causing one of the most significant thermal bypass areas. If the home is under a positive pressure (air pushing out from inside) in a heating climate, the air is likely to be at a high humidity level. This can cause frost, and eventually mold, to build up on the back side of the band joist. In a cooling climate that is under negative pressure (air pulled inward — a condition that's commonly caused by leaky HVAC ducts), this can pull hot, humid air from outside, where it is likely to condense and lead to mold problems. The sealing properties of ccSPF will reduce these air-infiltration and energy-loss problems in this troublesome area.

Attic and Crawlspace Bypasses

Attic and crawlspace bypasses are penetrations into the living spaces. Pipes, ducts, flues, and electric wires are the most common reason for these penetrations, and the best way to seal them is often (but not always) with ccSPF. Because ccSPF expands and seals, it does an excellent job of filling voids that allow conditioned air to escape. However, ccSPF should *not* be used to seal around high-temperature areas such as combustion appliance flues.

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The Structural Properties of Foam

Recent research conducted at the University of Florida has demonstrated that closed-cell spray foam (ccSPF) applied to the underside of roof decking effectively bonds the sheathing to the framing, significantly increasing uplift resistance. The study, conducted by Dr. David O. Prevatt and funded by Honeywell and Huntsman, two makers of ingredients that go into ccSPF, found that 3 inches of the foam sprayed between framing members provided a threefold increase in uplift resistance as compared with traditionally installed roof sheathing panels. While these results sound impressive, Dr. Prevatt points out that the increase provides the same benefits as increasing the nailing schedule to a 6/6 schedule (every 6 inches along panel edges and every 6 inches in the field) from the usual 6/12 schedule. What was perhaps most impressive is that using only spray foam to glue the sheathing to the framing provided almost as much resistance (178 to 209 psf) to uplift as does 8d common nails (205 psf) installed at the 6/6 schedule. This suggests what may be the biggest structural advantage of a foamed roof assembly — reducing the likelihood of a roof blowoff when the sheathing doesn't get nailed off with enough nails or when too many nails miss their mark.

UNIVERSITY OF FLORIDA CIVIL AND COASTAL ENGINEERING

A test panel (above left) in a study at the University of Florida simulates a roof assembly consisting of 1/2-inch OSB fastened to 2x4 framing at 24-inch centers. The framing bays have been filled with closed-cell spray foam. During the study, the assembly was placed on a pressure chamber and a vacuum pump (above right) drew a vacuum that was increased in 15-psf intervals until the assembly failed and the sheathing popped off the framing. For the fully foamed assemblies, this occurred at around 240 psf. The assemblies that had ccSPF fillets installed failed at 160 psf. The assemblies with sheathing alone nailed only with nails (6/12 schedule) failed at about 75 psf.

The uplift study also evaluated the benefit of installing a "fillet": a 3x5-inch bead of ccSPF in the corners between the sheathing and the roof framing. The fillet method effectively doubled the uplift resistance of the baseline assembly of 2x4 framing on 24-inch centers sheathed with 1/2-inch OSB nailed on a 6/12 schedule.

The uplift study is one of several recent studies of the structural properties of ccSPF. Tests conducted by Building Science Corporation (BSC) to evaluate the impact resistance of wall systems showed that conventional wood-framed walls do not have the same impact resistance as impact-resistant windows. (That is, walls consisting of studs, 1/2-inch OSB sheathing, housewrap, and siding cannot sustain the impact required by the ASTM E1886 and E1996 missile test, which hurls a 9-pound 2x4 at 50 feet per second.) The only test panel in the BSC demonstration capable of resisting the required impact load included a layer of 1/2-inch OSB sheathing between 1-inch foam insulating sheathing and 2 inches of ccSPF sprayed between 2x6 studs. Surprisingly, BSC found that a wall with foam sheathing, housewrap, and ccSPF (no OSB) performed better in impact tests than a wall with housewrap and OSB sheathing.

GARY'S ROOFING SERVICE

When a roof is not likely to be replaced anytime soon and the sheathing nailing can't be verified (on a tile roof in good condition, for example), contractors in Florida are beginning to employ the "fillet method." This practice uses closed-cell spray foam to help bond the roof sheathing to existing framing and provide a secondary water barrier.

The BSC study notes that walls may not have to be built to the same standard as windows, despite these surprising results. When a window fails under impact, the resulting hole in the wall (the entire window) is relatively large, providing a big enough hole to internally pressurize a home, which often leads to catastrophic failure. When a wall fails, the zone of impact is marginally bigger than the impacting face of the projectile. Such an opening may not be large enough to have a catastrophic effect. — *Clayton DeKorne*