

BEST-PRACTICE Energy Upgrades



Fire-rated vinyl-faced batts are an easy and effective way to insulate concrete basement walls.

I've been an energy consultant to Colorado builders for the past 20 years, and since 1993 I've done detailed performance tests on nearly 200 homes in the state. Based on that experience, here are the energy-saving features I most strongly recommend to both production and custom builders in my home state. All five measures are proven and widely accepted, which should make them equally useful to builders in other cold-climate areas.

by **Steve Andrews**

Tighten the Ductwork

Leaky ductwork is common everywhere, and it's a bigger problem than many builders realize. It reduces comfort and wastes energy, but it is also a potential safety problem. During one recent six-year period, there were 352 cases of carbon monoxide poisoning in Colorado alone, including 34 fatalities. The vast majority of the cases involved gas appliances, and although blocked flues were implicated in many of them, negative pressure is another troublesome issue.

How to get the most bang for the bucks you spend on energy and insulation

Figure 1. Ideally, return air should be ducted, but well-made panned joist returns also work well. The edges of this tin header are correctly sealed with mastic. The edges of the tin panning that will span the joists on the other side of the supporting steel beam will also need to be carefully sealed to provide a tight return-air cavity. Pipe and wiring penetrations must also be sealed.



Figure 2. Oops! Each extra elbow in this run of duct adds the frictional equivalent of 10 feet of straight pipe. The added resistance often means poor airflow, especially when the duct serves a bedroom over the garage, which already has higher-than-average heating and cooling demands.



Figure 3. In addition to lowering heating and cooling costs, upgrading to low-e windows will increase homeowner comfort and reduce or eliminate condensation and frost.

When more air is drawn out of the room than is being easily supplied, the result is negative pressure. If the negatively pressurized space is a basement, combustion gases can be drawn back down the flue and into the home. When those gases are reburned, they produce carbon monoxide.

The usual causes of negative pressure, in approximate order of importance, include leaky return-air ducts, fireplaces, down-draft kitchen exhaust fans, undersized cutouts through floor plates for return air drops, dryers, large combustion air ducts located on the sheltered (leeward) side of a home, and normal exhaust fans.

Testing for negative pressure. Fifteen to twenty percent of all new homes have a negative pressure problem, so here's a quick test that will tell you whether your home is one of them. It should be performed on every home with a basement: Close the basement door, turn the furnace blower on, and feel if air is rushing underneath the door from the house into the basement. If there is, the home has negative pressure in the basement, probably caused by leaky return-air ductwork.

A negatively pressurized basement is a potentially serious safety problem, and requires more additional safety testing than I can describe here. Call your heating contractor or local energy specialist for help. (If air is rushing out of the basement and into the house, on the other hand, you have a pressurized basement. That's an energy problem, but not a safety worry.)

Seal for real. Eliminate leaks by sealing ductwork on the outside with mastic. Another alternative is to use the new aero-seal procedure, which pressurizes the ductwork and shoots sealant into all the small holes from the inside. Whatever you do, don't use tape, which deteriorates rapidly with age. Emphasize to your heating contractor that you really want the return-air ductwork carefully sealed at potential sources of leakage: headers to floor joists (see Figure 1); drops from the floor joists into the return-air plenum; and top takeoffs at the plenum.

Finally, check the tops of plenums to make sure there are no exposed cutouts. In production homes, sealing your ductwork with mastic will typically cost between \$100 and \$250, depending on house size.

Sealing the ductwork will also reduce comfort problems, especially the annoying “Goldilocks effect” that often plagues air-conditioned homes: too cold in the basement (60 degrees or so), too hot on the second floor (78 degrees), and just right on the main floor (74 degrees.) This is often caused by leaky supply air ducts and supply plenums in the basement. While the warm air that leaks into a basement during the heating season will keep the floor warm and slowly rise through connections to the upper floors, cool air leaking into the basement during the summer just stays there. Sealing the ductwork increases the pressure in all supply ducts, which improves the chances that heated or cooled air will be delivered to those hard-to-reach bedrooms over the garage.

Plan ahead. Besides leaky ductwork, it's poor ductwork design that prevents conditioned air from reaching its destination. Ninety-nine percent of the new homes I've worked with never had a sheet in the floor plans showing how and where ductwork would run. Drawing an HVAC plan will reveal potential conflicts between ducts and plumbing drains or other systems, and helps reduce the tendency to install long duct runs with so many elbows that air resistance will prevent adequate airflow (Figure 2).

Upgrade the Windows

Your best opportunity to reduce conductive heat loss and improve indoor comfort is to add insulating value to these building components that are losing the most heat to begin with. In other words, before you add insulation to the attic, which usually has an insulating value of at least R-30, it makes sense to upgrade your windows.

Switching from metal to vinyl windows, for example, typically increases their insulating value from R-1.5 to R-2.



Figure 4. Use a smoke pencil to check the seal between the garage foundation wall and drywall. This joint must be sealed with urethane caulk, an EPDM gasket, or expansive foam to prevent negative pressure from drawing toxic fumes into the basement.



Figure 5. The flue is correctly sealed where it enters the sheet-metal covering at the bottom of the chase. But the edges of the plate should also have been sealed.

To put that another way, the R-1.5 window loses heat 20 times as fast as a square foot of attic, while the R-2 window loses heat only 15 times as fast. Going to windows with a typical low-e coating increases their R-value to R-2.5 or better, and a low-e coating combined with an insulating gas filling brings it up to R-3 or so.

On a 2,000-square-foot house, the move from R-2 to R-2.5 windows will bump the overall price of the window package by something like \$250 to \$400, but upgrading all the way to R-3

will cost only \$50 to \$100 more. Compared with the cost of upgrading to better windows ten years down the road — when energy prices may be much higher than they are today — that has to be seen a tremendous bargain.

Better windows make a better house. Upgrading windows from R-2 to R-3 does more than just reduce heat loss. On a cold night, the surface of the R-3 glass may be ten degrees warmer, increasing comfort and reducing the chance of condensation forming on the glass (Figure 3). It reduces fabric fading

Sealing Interior Soffits

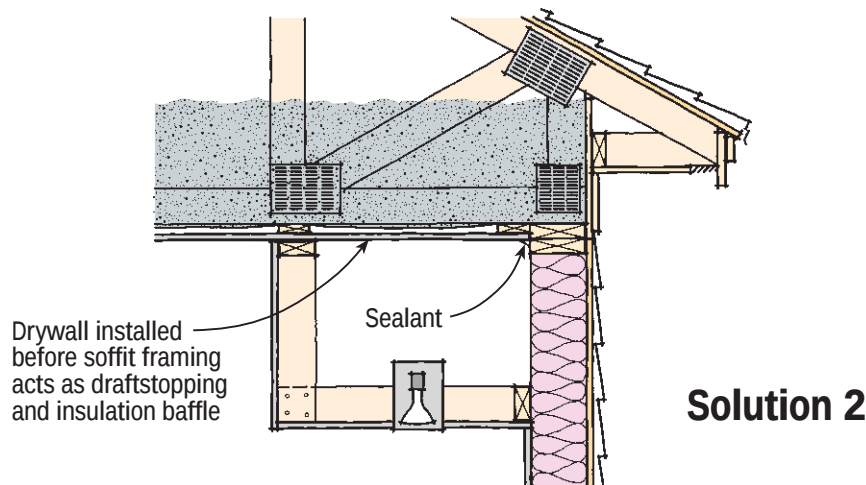
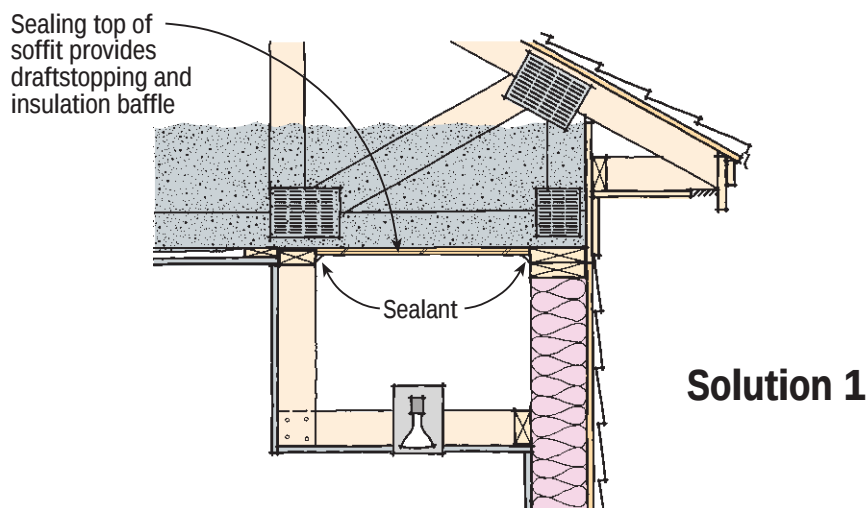
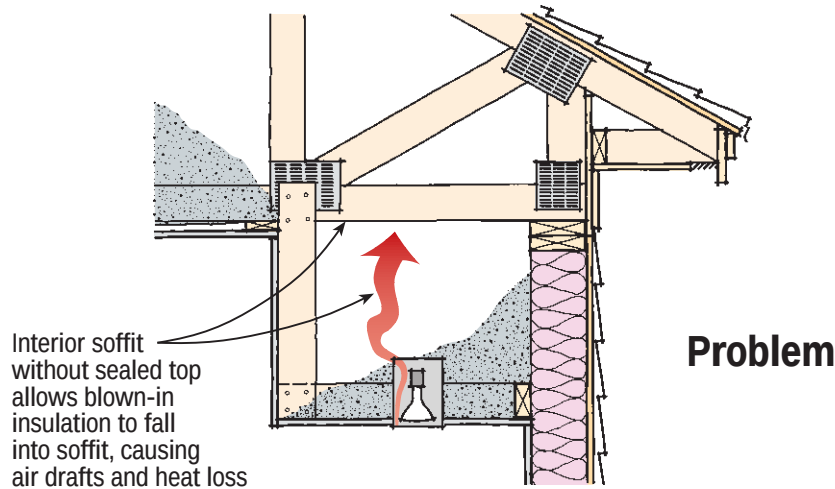


Figure 6. Interior soffits are common sources of heat loss. In the top illustration, the cellulose insulation that was blown toward the eaves wall has fallen into the soffit, allowing heat to radiate through its uninsulated vertical wall. The recessed can light compounds the problem by allowing heated air to escape to the attic as well. One solution is to seal the open top of the soffit with plywood as part of the framing process, providing a flat surface that can be easily insulated from the attic (middle). Better yet, first drywall the ceiling above the soffit, then frame and drywall the soffit itself.

caused by UV radiation and increases long-term resale value. In homes with large expanses of unshaded east and west-facing windows, upgrading to low-e glass can prevent overheating on sunny days and reduce the cost of air conditioning. In an air-conditioned house with a large heat gain, low-e glass may be cost effective on the basis of cooling alone.

Build Tight, Vent Right

Tests indicate that attics account for about 40% of the air leakage in a typical two-story home. The crawl space, rim joist, and garage account for 30%, with another 10% issuing from the pair of six-inch combustion air ducts in the basement. Air leaks through windows, doors, and exterior walls kick in another 10% to 15% percent, and 5% to 10% comes from cantilevers close to ground level.

Start with the garage. But the single biggest concern is leaks around the garage door bringing air into the house through penetrations in the drywall, or between the drywall and concrete (Figure 4, previous page). That air carries with it a toxic soup: carbon monoxide after a car starts up, plus effluents and off-gassing from turpentine, paints, gas cans, power equipment, and cleaning products. (That's why you stuff all this junk in the garage, right?) The solutions are straightforward: After drywall is installed, seal all joints between drywall and concrete, then caulk all penetrations and seal any cantilevered chases which run up into a second floor. On average, this should take one person about 20 minutes. We're not talking about a big hole here, just a really bad one.

The largest leaks into attics are generally chases tied to entertainment centers, fireplaces, flues, and decorative or architectural support columns. Seal flues with sheet metal and caulk (Figure 5, previous page). Seal the open tops of interior soffits with any suitable rigid or sheet material, such as pieces of Thermoply or foil-faced bubble-pack insulation (Figure 6). A surprising amount of air leaks up through parti-

tion walls. Have your insulator seal this from the attic after drywall is installed, using a hand-held canister and spraying a thin coat of foam over the plate/dry-wall connections.

Sealing a partial at-grade crawlspace from the house is often impractical, and always time consuming. The better strategy is to build an unvented crawlspace, then seal the crawlspace from the exterior, placing a carefully sealed vapor barrier down on the ground, and heat the space (see "Crawlspace Ventilation Update," 8/99).

Ventilation made simple. The "ventilate right" part of this equation can be accomplished in two ways. First, you can upgrade your existing kitchen and bath fans. A recent market survey by a utility in my area indicates that the dinky little bath fans installed in most homes are so noisy that homeowners hate to use them. Going to a quiet bath fan costs from \$75 to \$100 per fan. Upgrade at least one controller with an intermittent timer so the bath fan runs part of every hour of the day, providing limited ventilation year-round. Replace unventilated kitchen fans with a quiet fan that is always ventilated to the outdoors.

The second option is a cheapo approach to whole-house ventilation: Install a fan recycler controller (Aircycler, Lipidex Corp, 50 Franklin Terrace, Duxbury, MA 02332; 781/834-1600; www.aircycler.com) that enables a furnace blower to provide ventilation all year. If your furnace or air conditioner hasn't run for an hour, the controller turns the blower on for five minutes. Whenever the blower operates, a small duct on the return-air side of the unit brings fresh air in through a duct to the outside and circulates it throughout the home. Several production builders working with the Building America program have opted for this approach, which costs only about \$150 to \$200 to install.

Attack the Attic

As I mentioned earlier, most attics have enough insulation. But many attics have little flaws that can eventu-



Figure 7. Energy trusses provide full insulation depth all the way to the outside face of the wall. The addition of cheap blocking will keep loose-fill insulation from falling into the interior soffit cavity.



Figure 8. Sloppy batt installation, and a thermal canyon excavated by the electrician. You get what you *inspect*, not what you *expect*.



ally cause big problems, such as mold and mildew in uninsulated corners.

If you're building with conventional roof trusses, for example, there are only 2 to 6 inches of insulation covering the first foot and a half of your attic next to exterior walls, except along gable ends. Solution: Use energy trusses (Figure 7, previous page), so there's room for at least 6 inches of insulation over the top plates.

Blown cellulose can't be used to insulate above cathedral ceilings, because the loose insulation tends to slide down the slope and pile up at the top of the adjoining wall. Fiberglass batts are the usual choice in this application, even though gaps between batts or compression caused by wiring can significantly reduce the insulation's performance.

If you also have some flat ceiling that calls for cellulose, though, there's a simple solution to this problem: Blow an R-11 layer of loose-fill cellulose over the fiberglass batts to cover the gaps and other imperfections. On moderate slopes — up to 5/12 or so — the texture of the batts will keep the loose fill from sliding off. The trick here is to make sure you get enough batt material down at the base of the ceiling, where the lack of

clearance between the batts and the roof decking make it awkward to blow in the cellulose.

It's the installation, stupid. Advocates of blown fiberglass like to claim that cellulose settles, thereby losing R-value. The cellulose crowd counters that fiberglass installers often install their product at too low a density ("fluffing"), thereby losing R-value. Though the charges contain some truth, both products, when properly installed, will provide the stated R-value.

What really matters is the quality of the installer's work. I inspected an attic last week where there was no attic insulation six months into occupancy, although the builder had paid for it (Figure 8, previous page).

Insulate the Foundation

Like windows, concrete foundations are a major source of conductive heat loss. In states and localities that use the model energy code, you pretty much have to insulate every part of your foundation, and it's a cost-effective measure in all cold-climate areas. Don't forget the slab edges, as far too many builders do.

Blankets and ICFs. In unfinished basements, the most common solution

is a vinyl-faced R-11 or R-19 blanket attached to the inside of the concrete foundation walls (see photo, page 1). If the basement will be finished, consider using insulated concrete forms (ICFs). You can simply screw the drywall to the facings of the spacers which hold the two walls of foam apart. Most ICFs provide insulation values that fall between R-14 and R-22. Going with ICFs also means that you'll need less concrete — an appealing thought as we emerge from a year in which the supply of concrete was sometimes tight. The less concrete you use, though, the more steel rebar the ICF system engineers will require.

Crawlspaces and shallow foundations. In crawlspaces, insulate the concrete stem walls with fiberglass batts (go with R-11, R-13 or R-19 batts, depending on your climate), securing them as for a full basement wall. In my area, the building codes permit the use of unfaced batts in crawlspaces, rather than the vinyl-faced batts required in basement applications. Make sure that the bottom edge of the batt "curtain" extends beyond the base of the footing, not just to the bottom of the wall, and remember to insulate the rim joists.

For an on-grade slab, consider using some form of shallow foundation (Figure 9), which is thermally efficient and far less costly than a conventional slab and stem wall (see "Frost Protected Shallow Foundations," 9/96, and "Pouring a Shallow Frost-Protected Slab," 8/97).

If the slab will be heated directly — either hydronically or from passive solar gain — don't forget to insulate it from beneath with rigid foam. In a cold heating climate of 4,000 degree days or more, I recommend a minimum value of R-5 in this application. In severely cold climates or in a home that will be heated with an expensive fuel such as propane, R-10 would be a better choice.



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Figure 9. Cost savings associated with an energy-efficient shallow foundation can be plowed back into additional energy upgrades.

