Encapsulating ducts with at least 1 1/2 inches of closed-cell spray foam substantially improves HVAC performance in all U.S. climate zones. Burying the encapsulated ducts in loose-fill attic insulation improves performance even more.

Photos: Steven Winter Assoc./CARB

Buried and Encapsulated Ducts

Why is it so common—particularly in warm climates—to find air conditioning ducts, and even air handlers, in the attic? Isn't it hot as hell up there? It seems counterintuitive to route the cool air intended to condition a home through that space.

It is, in a way. But as I've learned, there are good reasons for running the AC through the attic. The obvious ones: It's easier to run supply ducts throughout a house that way, and it's more affordable—attics on a house with a sloped roof typically don't cost anything extra. (Compare that with running the supply ducts through basements—common in the Northeast. Though convenient, this option is a super-expensive way to run heating ducts.) But it also makes more sense to locate cooling supply outlets up high—in the ceiling or high on the wall—than in the floor. Cool air wants to fall and will cool the whole volume of a room on its descent. When cooling supply ducts are in the floor or located low on the wall, the air tends to stratify, with the coolest air staying near the floor and the warmer air up high—not the most comfortable distribution in a room.

But for all of the convenience and logic in favor of distributing cool air via the attic, we pay a huge penalty for running that air through the hottest space in the house. R-8—the highest-R flex duct typically available—offers only minimal help when there's a 65°F or greater difference between the air in the ducts (around 55°F) and the attic air (120°F or more). And then there are all the duct leaks of a typical install: supply leaks through which cool air is lost to the attic, and return leaks through which hot air is sucked into the system. System inefficiencies are greatest during peak demand conditions when the attic is hottest and system run times are longest.

The issue is not simply energy loss, though. There can be comfort issues, as well. When the HVAC system isn't running, the air inside the ducts heats up or cools down substantially, depending on the season. When the system kicks back on, this hot or cold air is pushed into the conditioned space—an unpleasant blast of air that increases the space-conditioning load.

It's no wonder that energy professionals have been telling builders and designers for years to run HVAC ducts inside the building envelope. Valiant efforts have been made to incorporate ducts in dropped ceilings and soffits ("fur-down" model), or to employ custom "plenum trusses" that provide a duct chase above the ceiling ("fur-up" model). But adoption of these methods has been slow going, especially among production builders, says Bill Zoeller, project manager for the Consortium for Advanced Residential Building. (CARB is one of the research teams in the U.S. Department of Energy's [DOE] Building America program that works with builders to improve home energy efficiency.)

CARB's work on ducts started when one big builder it was working with pushed back on recommendations to drop the ceiling so that ductwork could be run inside the insulation and air barrier. The builder wasn't willing to sacrifice ceiling space, Zoeller says, but was willing to run the ducts close to the ceiling plane in the attic and pile more insulation over them. Doing just this improved HVAC performance enough that the DOE asked the CARB team to run some metrics to quantify the improvement in energy savings in all climate zones.

Work in hot, humid climates revealed a problem. While the added insulation provided lots of thermal resistance to prevent the hot attic air from warming the air in the ducts, it lowered the temperature of the duct jacket, allowing it to fall below the dew-point temperature. This allowed condensation to form on the outside of the ducts when attic humidity was high. The solution: Spray at least 1½ inches of closed-cell foam on the outside of the duct. (Note: At least 1½ inches of mineral fiber insulation is required as an ignition barrier over spray foam, unless the foam is approved for use without an ignition barrier. See "Making Sense of Spray Foam and Ignition Barriers," Nov/12.)

In CARB's field studies, during which the team monitored temperature levels, the combination of burying ducts in loose-fill insulation and encapsulating them in closed-cell spray foam showed no potential for condensation. The tests demonstrated that encapsulating the ducts brought the existing R-4.2 flexible ductwork to values between R-9 and R-13, depending on duct size. Burying *and* encapsulating ducts increased R-value to levels between R-16 and R-31. In addition, the spray foam substantially reduced duct leaks, bringing the leak rate to a level comparable to that in houses with air-handling units in the living space. Zoeller recommends that ductwork be sealed with mastic prior to insulating, even when encapsulating. It's the sort of belt-and-suspenders approach that makes most energy measures work.

Duct encapsulation. Top: before drywall; bottom: after drywall.

Zoeller reports that adoption rates for installing buried and encapsulated ducts both in new construction and in retrofit applications have been promising. Most HVAC contractors need a little direction the first time through when routing ductwork near the ceiling plane. "The problem," Zoeller says, "is that a lot of contractors don't think about it. They just start running duct, and the result is often a confused mess." Offering a little direction in advance forces them to think more carefully about it, which by itself is bound to improve duct performance.

Clayton DeKorne is executive editor of JLC. *For more information, search for the "Building America Measure Guideline: Buried and/or Encapsulated Ducts" at the EERE Library (www1.eere.energy.gov/library).*