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# Still Placing Ducts in the Attic?

## Consider Burying Them

Heating and air conditioning ducts running through 130°F or 10°F attics are subject to some pretty hefty thermal penalties. Over the years, Steven Winter Associates, Inc. (SWA) has explored many ways to reduce the significant energy penalties caused by heating and cooling ducts located in attics. While there are many ways to reduce this load, such as moving ducts into conditioned space, insulating roofs instead of ceilings (unvented attics), using non-ducted systems for heating and cooling, etc., all of these typically require significantly more time, materials, and/or money to implement. Because of those cost and time considerations SWA has investigated a potentially simpler, and cheaper, approach.

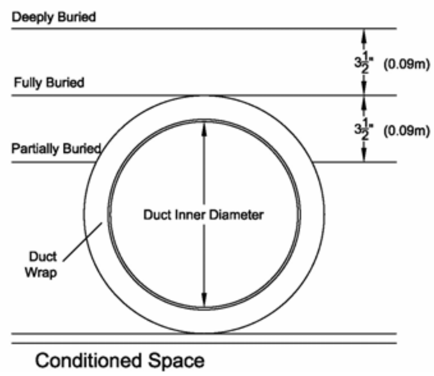
There has long been debate in the homebuilding industry about the wisdom of burying ducts that run through vented attic space. The primary concern is the potential for condensation. Condensation occurs only when the surface temperature of the duct falls below the dew point of the ambient air. Proponents note that placing ducts under loose-fill insulation reduces conductive heat gains in the summer and heat loss during winter, and that with tightly sealed ducts in dry climates, substantial load reductions are possible without concern of condensation.

SWA has investigated the overall implications (energy and durability) of burying HVAC ducts under loose-fill attic insulation. We began with modeling the heat transfer with ALGOR, a finite-element analysis software. SWA explored construction variables that affect the performance of buried duct systems (such as the depth and configuration of insulation) in order to optimize the design and to establish guidelines for predicting the performance of buried duct systems.

What did the simulations show? Standard R-4.2 flex-duct systems, for instance, that are deeply buried in 3½ inches of insulation have an equivalent R-value of ~28; duct systems with main trunks partially buried (3½ inches of the duct exposed) yield an R-value of ~9. Insulation just covering the top of the duct yields an R-value of ~14. While the thermal resistance is increased by covering the duct with more insulation, the potential for condensation also increases.

SWA applied lessons learned through computer simulation in houses constructed by the Northern California division of Beazer Homes. Under California's Title 24 requirements, new homes must have no more than 6% duct leakage. This tight duct requirement in a dry climate is essential for duct burial under loose-fill insulation. This study revealed a significant impact on reducing peak-demand. For example, for a 1,540-square-foot house in Sacramento, peak load was reduced by a half-ton using an R-15 buried duct systems, as compared to hung ducts.

SWA's research into the effectiveness of buried ducts interested officials at the California Energy Commission (CEC). Following additional research and the development of a prescriptive compliance tool, the buried ducts option was made available as an alternate method to reach residential Title 24 compliance in the 2005 and later codes.




**Effective R-values for R-4.2 ducts buried beneath blown-in insulation.**

| Loose Fill Insulation Type | Buried Duct Classification | | |
|---|---|---|---|
| | Deeply | Fully | Partially |
| Fiberglass | 25 | 13 | 9 |
| Cellulose | 31 | 15 | 9 |

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**Achieving Credit Under Title 24**

To receive credit for "buried ducts" under Title 24, a minimum of R-30 insulation must be blown after the HVAC ducts are installed. Prior to being buried, the ducts must have at least R-4.2 duct insulation, the lowest point of the insulating jacket must be within 3.5 inches of the ceiling gypsum, and there is at least six inches of space between the outer jacket of the installed duct and the roof sheathing above. The buried duct classification is based upon insulation uniform depth throughout the entire area of the attic; it can't just be mounded over the ductwork. These criteria need to be certified by a HERS rater. This can be done with an inspection of the ductwork rough-in during the pre-drywall inspection and a final inspection during duct leakage testing. Clear indicators of the installation of buried ducts needs to be located to verify proper installation and inform homeowners/contractors of their presence.

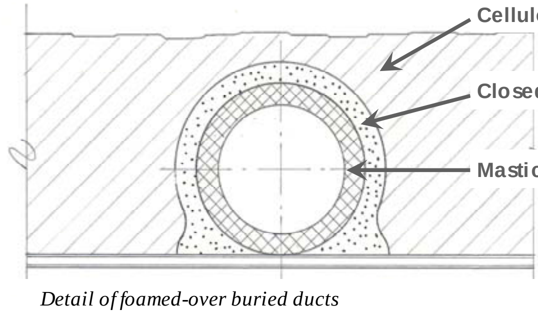
The next step was to figure out how to bring the benefits of the buried duct technology researched in hot, arid climates to regions that are hot and humid. The concern with burying insulated ducts under the attic insulation in a mixed-humid or humid climate is that the surface temperature of the ducts' vapor-barrier jacket may, during certain conditions, be below the dewpoint of the surrounding air, thereby causing condensation. Steady-state calculations based on psychometric theory suggest that condensation could occur. However, the problem is transient in nature because the air conditioning system cycles on and off. The extent of the period when the air conditioning system is operating and the attic temperatures are still moderate is not well defined. With these uncertainties, CARB worked with Mercedes Homes in Melbourne, FL to monitor an actual installation to investigate this issue further.

Based on over six months of data analysis, condensation did occur for brief periods of time. Leakage of conditioned air from the ducts or through ceiling penetrations appeared to minimize the severity of problems, but leakage should not be relied upon, and for other reasons, avoided.

**Design and Installation Guidelines**

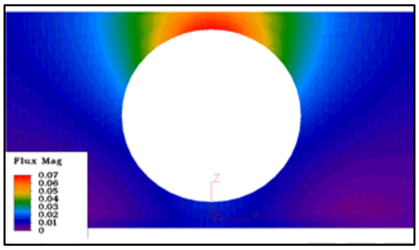
Burying ductwork needs to be considered in the design process of the roof trusses. A buried-duct design should keep ducts as low as possible in runs parallel to attic framing. Crossing framing or other obstacles raise ducts out of the insulation and should be minimized. Attics with stick framing (rather than roof trusses) are especially challenging—ceiling joists are often 2x8s or 2x10s, and ducts running across these joists will be well above insulation levels. Fink style roof trusses work well as the "W" shape allows for the supply trunk to be laid centrally on the bottom chord. This allows the supply branches to be run between the trusses. Depending on the depth of the bottom chord, takeoffs can be dropped from the side or bottom takeoffs can be utilized to keep the supply branches close to the ceiling plane. Side-entry boots should be utilized for the duct terminations.

SWA worked with Outlook Construction in Georgia, to devise a method to prevent possible moisture condensation on the ducts' vapor-barrier jacket when utilizing the buried duct technology in humid climates. A flex-duct system was installed in the attic (tight to the ceiling plane) and




*Detail of foamed-over buried ducts*

covered with one-inch of closed-cell sprayed polyurethane foam. The combination of the flex-duct insulation (R-6) and the foam (R-7) yields an R-13 insulated duct system. Blown cellulose insulation was then installed over the foamed ducts. SWA monitored duct performance and the polyurethane was shown to provide as an effective vapor retarder, preventing moisture diffusion between the attic and the ducts.




**Heat flux profile during cooling**

The primary advantage of the foam is that it controls condensation that typically occurs when hot, humid attic air comes in contact with ductwork containing cooler conditioned air. In addition, the closed-cell foam creates a vapor retarder so that moisture from hot humid ambient air doesn't permeate the insulation layer. The dewpoint, which is located at a point inside the insulation, is protected by the closed-cell foam covering.

A secondary benefit is that the foam insulation acts as a backup to the mastic sealant, providing additional air sealing. Foam has the advantage of being easier to apply in hard-to-reach places. The air sealing properties are especially beneficial around registers that penetrate the ceiling (an area that is typically prone to leakage).

The application of foam insulation adds yet another benefit. The technique has been found to reduce conductive losses, leading to reductions in the system peak load.

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