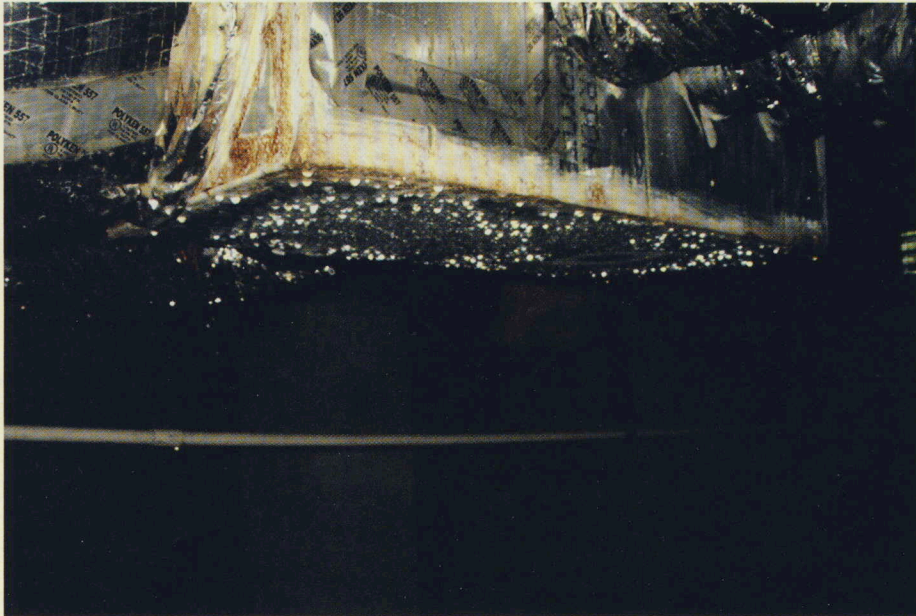


Closed Crawl Spaces



Humid air entering a vented crawl space from outside can condense on cold surfaces, soaking the insulation, and leading to mold, rot, and termite problems. Such problems are most likely in homes with air conditioning.

Foundation vents are as likely to draw humid air into a vented crawl space as to keep it out. That may not have been a problem before air conditioning, but with homeowners setting indoor temperatures to 70 F or less in summer, the entire house frame can cool to below the air's dew point. That leaves plenty of surface on which moisture can condense, and mold can grow.

Advocates of sealed and insulated crawl spaces claim that their approach minimizes such problems while also lowering energy bills. Recent studies conducted by Raleigh, N.C.-based Advanced Energy Corp. (AE) found that closed crawls are a great moisture control strategy anywhere—and if properly detailed may help reduce home energy bills.

Insulation and Duct Placement

AE monitored three sets of homes in three different climates: hot, humid Baton Rouge, La.; cold, dry Flagstaff, Ariz.; and the mixed climate of Princeville, N.C. Each location included four control homes with vented crawls, and four to 12 homes with sealed foundations and either wall or floor insulation.

HVAC supply ducts ran through the attic in some homes and through the crawl in others.

To keep out ground-borne and airborne moisture, installers sealed gaps in the foundation and floor frame with spray foam, then covered the walls and ground with 6-mil reinforced clear polyethylene. A small supply duct delivered just enough dry air to get rid of any moisture that did get in.

AE measured crawl space humidity and home energy bills for over a year in Princeville and Baton Rouge, and for one heating season in Flagstaff.

Moisture Control. As the table on page 48 shows, all of the closed crawls stayed drier than the controls, regardless of insulation or duct placement. These results confirm that correctly detailed closed crawls can reduce moisture problems in all parts of the country.

Energy Savings. While moisture reduction was consistent, energy savings varied with climate, insulation, and duct placement. In Princeville, for instance, homes with closed crawls used 15% to 18%

AT A GLANCE

Benefits >

> Properly detailed closed crawls have lower relative humidity and are less prone to condensation, mold, rot, and bug infestation than vented crawls. They can also help reduce energy bills if climate appropriate insulation strategies are used.

Drawbacks <

< In areas where radon gas is a problem, a mitigation system may be needed.

Initial Cost

> Cost for new construction should average \$2 to \$3 per square foot. Cost for a retrofit can range from \$6 to \$7 per square foot. The variables include the condition of the existing insulation, the extent of mold growth, and whether the crawl space needs to be graded. Some contractors add a surcharge for crawl spaces with less than 3' of headroom.

Tax Rebates and Incentives

> While there are no specific tax advantages related to closed crawl spaces, retrofitting an older home with floor or foundation wall insulation may qualify it for energy tax credits.

Operational Cost

> The only cost is for the tempered air delivered to the crawl. However the volume of this air is less than most homes' natural rate of air leakage.

Maintenance

> Watch for plumbing leaks and breaks in the air seal. The seal should be inspected annually and after any work is done in the crawl. The space should have a wireless humidity meter paired with an alarm inside the house. The meter's batteries should be changed during the inspection.

U.S. Code Acceptance

> Energy codes allow vented and unvented crawl spaces but have specific requirements for insulation and vapor retarders. Codes may also prescribe the amount of conditioned air that must be mechanically delivered to the space.

For More Information

> www.crawlspaces.org

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Photo courtesy: CrawlSpace Care

PRODUCT SOURCES

The following companies supply contractors with the specialty materials and equipment needed to properly seal and insulate a crawl space. Products include fiberglass-reinforced wall and floor liners, adhesives and tapes, dehumidification equipment, and moisture meters.

> www.crawlspacesproducts.com

> www.crawlspacesupply.com

Making the Switch

Some things to think about before switching to this technology:

> Make sure there's enough headroom—at least 3' from the dirt floor to the bottom of the floor joists—to work comfortably in the crawl.

> In all climates, HVAC ducts will perform better in a closed crawl space than in an un-insulated attic.

> In a hot climate, it's preferable to insulate the foundation walls.

> In a cold climate, it's preferable to install fiberglass batts between the first floor joists.

> In a mixed climate, wall or floor insulation are both acceptable.

> When using wall insulation, make sure to leave a termite inspection gap at the top of the wall.

> Test all closed crawl spaces for radon gas.

> Install a wireless humidity meter connected to an internal alarm.

> Use only sealed combustion equipment that is directly vented to the outside.

In a closed crawl space, all gaps are filled with spray foam sealant or weather-resistant caulk. A fiberglass-reinforced polyethylene vapor retarder with a minimum thickness of 8-mil is used to cover the dirt floor; 6-mil poly is used to cover the foundation walls and all piers. The fiberglass reinforcing makes it much less likely that the poly will be punctured by rocks in the soil, or by maintenance contractors who need to enter the space.

less energy than the controls, regardless of what type of insulation they had.

In Flagstaff, closed crawl homes with floor insulation used 20% less energy than the controls while those with foundation wall insulation used 53% more. Cyrus Dastur, the AE building scientist who directed the research, concluded that, without floor insulation, heat radiated from the home's conditioned space to the cold ground in the crawl. He believes that floor insulation is the best strategy for closed crawls in a cold climates.

Baton Rouge results varied from a 6% savings to a 29% penalty. But those numbers depended as much on duct placement as on insulation. Among homes with attic ducts, those with wall-insulated crawls only performed better than the controls for part of the year, while homes with ducts in wall-insulated closed crawls used less energy all year. The researchers concluded that, in a hot climate, you will optimize energy performance by placing ducts in a wall-insulated closed crawl space.

Things To Watch For

Concerns with closed crawls include radon, floods, and the integrity of the air seal. Radon gas buildup has always been a worry with closed crawls, and indeed the Flagstaff homes' crawls were re-opened after the study because of high radon levels. Dastur advises builders to test for radon in all homes. In areas known for radon, soil gas exhaust piping can be roughed in during construction.

The most likely source of flooding is a plumbing leak (assuming proper downspouts and exterior grading). Dastur says that while some research homes developed plumbing leaks, the tempering



Here, a small duct delivers just enough conditioned air to the crawl space to dry out any moisture that manages to sneak past the poly and the foam. AE recommends an air flow of 1 cubic foot per minute per 30 square feet of crawl space floor area. Airflow can be controlled by a balancing damper or constant airflow regulator.

ducts were enough to keep the air dry in their crawl spaces. Billy Tesh of Pest Management Systems, a contractor in Greensboro N.C., was recently asked to clean up a closed crawl that had been flooded by a burst pipe. After pumping out the liquid water and mopping up the remaining puddles, the tempering duct dried the crawl space within an hour.

Dastur also recommends that the crawl space soil be graded to slope to one end of the foundation. If possible the builder should install an emergency drain that drains floor water to daylight; if that's not possible, a sump pump should be installed.

The main long-term concern is the air seal. In one home, a satellite TV installer punched holes in the plastic, despite a sign inside the access door warning that the crawl was sealed. Because of this, a closed

CHECKLIST

Below is a checklist of steps to follow to implement this technology in each of your projects:

Waterproof the foundation, and grade and slope the crawl space area so that water will flow to a low point.

Perform termite soil pre-treatment.

Install wall vapor retarder and Thermax insulation board.

Line the top of the foundation wall with sill seal before installing the wood sill.

When the floor framing is complete, treat the wooden subflooring with a mold treatment such as Mold-Ram.

If necessary, lay temporary poly on the crawl space floor and use a temporary dehumidifier to keep the space dry during construction.

Combustion appliances (furnace, water heater, etc) within the crawl space must draw combustion air from outside.

Seal all penetrations between the crawl space and the living areas.

Apply insulation the exposed interior surfaces of the band joist.

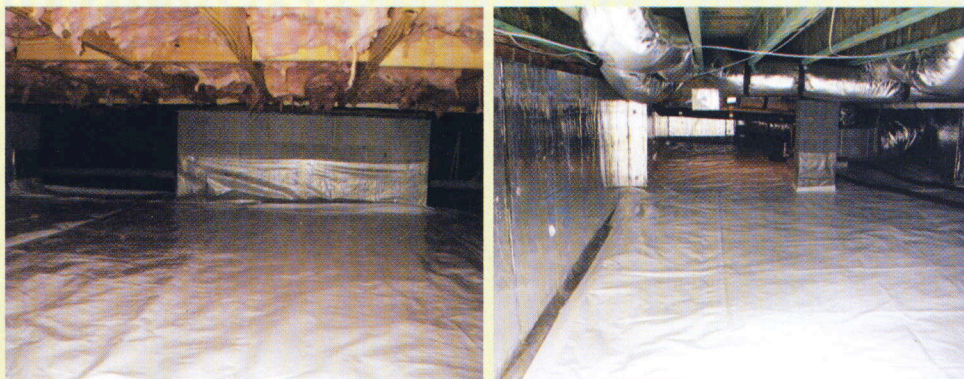
Supply your HVAC contractor with 8-mil floor liner to place under air handler and supply air inducers.

Remove all wood debris, clean out the crawl space, install a sump pump or a drain that leads to daylight. Install 8-mil floor liner. Install door insulation and seals.

Install a warning sign and a thermo-hygrometer inside the crawl space.

Complete termite pre-treatment.

Keep the vapor retarder clean.



In some cases, fiberglass batt insulation is placed between the floor joists; in others, rigid foam board is fastened to the walls. Which is best depends on the climate. (See table below.) In the picture, note the termite inspection gap at the top of the wall insulation.

crawl should be fitted with a wireless humidity meter paired with an alarm inside the house. Regular inspection is also important: Tesh's company offers a yearly maintenance package where they check the air seal and change the batteries on the moisture meter. Padlocking the crawl space access door isn't a bad idea, either.

The biggest challenge may be finding qualified installers. Homes in this study

were detailed by professional energy contractors—E3 Energy detailed the Flagstaff homes, while Pest Management Systems did the work in Baton Rouge. Tesh also co-owns another company, CrawlSpace Care, that provides training to installing dealers. In addition, Advanced Energy is developing a training curriculum that it hopes to offer through utility companies and builder groups. ⁶⁸

Number and Location of Homes	Insulation	Location of HVAC Supply Ducts	Summer RH (Versus RH in controls)	Energy Use Compared to Control Homes
Princeville, N.C.				
4	R-19 Floor Insulation	Crawl Space	<60% (vs >90%)	15% savings
4	R-13 Thermax Wall Ins	Crawl Space	<60% (vs >90%)	18% savings
Baton Rouge, La.				
4	R-19 Floor Ins	Attic	60% (vs >80%)	29% penalty
4	R-8 Thermax Wall Ins	Attic	60% (vs >80%)	20% penalty
3	R-8 Thermax Wall Ins	Crawl Space	60% (vs >80%)	6% savings
Flagstaff, Ariz.				
4	R-30 Floor Ins	Crawl Space	<50% (vs >70%)	53% penalty
4	R-13 Thermax Wall Ins	Crawl Space	<50% (vs >70%)	20% savings

Advanced Energy studied three groups of homes in different climates to see which closed crawl space design worked best. As the table shows, closing the crawl reduced moisture levels in all homes, regardless of where the insulation was placed. However, homes in the heating-dominated climate of Flagstaff, Ariz., used less energy with floor insulation, while those in Baton Rouge's cooling climate performed better with wall insulation. In the mixed climate of North Carolina, the two insulation strategies worked equally well. AE says that the Baton Rouge number should be considered preliminary, and they are planning a follow-up study to better quantify the savings or penalties in that part of the country.

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Left photo courtesy Advanced Energy; right photo courtesy CrawlSpace Care