CRAWL SPACE SCIENCE

Crawl Space Encapsulation: Is All That Plastic Necessary?

What a closed crawl space actually needs, what the Advanced Energy field research shows about sealed liners versus overlapped, pinned ground barriers, and how to judge each component by what it does for the wood.

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The "Cadillac," a few years later. A sealed wall liner in a Hampton Roads crawl space, chewed through by rodents, with droppings on the liner below.

Summary

Encapsulation contractors in the coastal Southeast routinely sell fully sealed crawl space liners, with taped seams, wrapped piers and covered foundation walls, as the premium solution to crawl space moisture. Complete packages commonly run **$15,000 to $30,000**. This paper asks a narrower question than the sales pitch does: does the extra plastic keep the structural wood any drier?

A closed crawl space needs three things working together: air sealing, a ground vapor barrier and a reliable drying mechanism, plus drainage where groundwater is present. The research question is whether sealing every seam and covering every wall adds enough measured benefit to justify its cost, its maintenance burden and the loss of inspection access.

Key findings

- In Advanced Energy's Phase III field trials for the U.S. Department of Energy, three crawl spaces were closed **without sealing the ground vapor retarder or installing any wall vapor retarder**. They "quickly exhibited performance similar to that of the other closed crawl space designs."
- On structural wood moisture, the unsealed group averaged about **11.0%** with a maximum of about **12.4%**. The sealed-liner group averaged about **10.7%** with a maximum of about **12.6%**. Both are well below levels that support decay.
- The unsealed group ran at higher relative humidity than the sealed groups (average daily RH below 70% versus below 60%). The difference showed in the air, not in the wood.
- In a typical 1,500-square-foot, 20-inch coastal crawl space, a sealed liner with taped seams, covered walls and wrapped piers costs about **$7,500**, against about **$2,800** for a pinned 12 mil woven barrier: roughly three times the price for the liner work alone.
- Covered walls and wrapped piers hide termite tubes, cracks, rodent entry and water intrusion in a space every trade eventually has to service.
- IRC R408.3 sets prescriptive requirements for new closed crawl spaces. It is not automatically the prescription for repairing an existing one.

1. Where crawl space moisture comes from

In vented crawl spaces across coastal Virginia and the humid Southeast, a major summer moisture source is hot, humid outdoor air entering through foundation vents and other openings. That air carries a high dew point. When it reaches framing, ducts or pipes cooled by the air conditioning above, surfaces below the dew point collect condensation.

Moisture also evaporates from exposed soil. And some homes have a separate problem: bulk groundwater entering after rain. Each cause needs its own repair:

Moisture source	Repair
Humid outdoor air through vents and openings	Seal exterior air openings
Evaporation from the soil	Cover the soil with a ground vapor barrier
Remaining moisture load	Conditioned supply air or a dehumidifier
Bulk water after rain	Correct the drainage

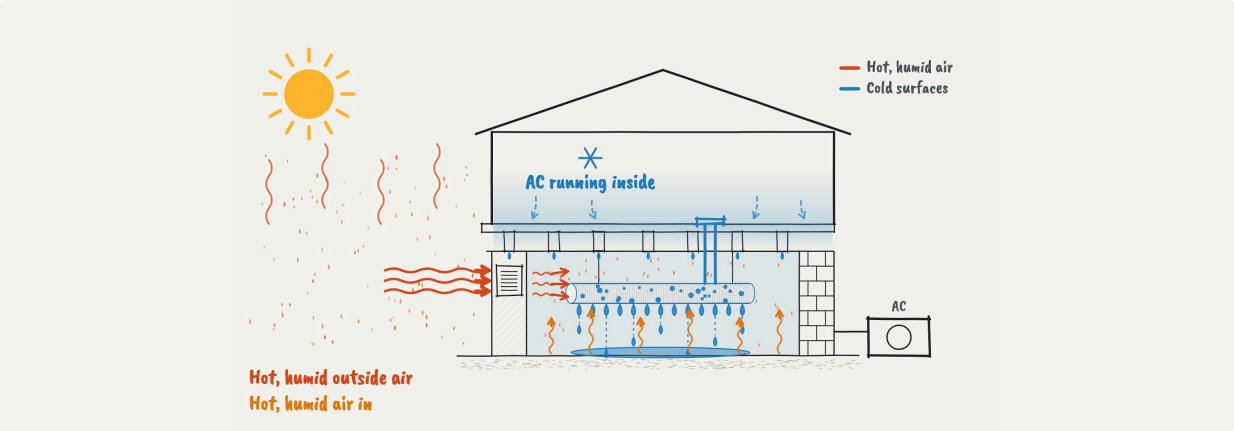


Figure 1. A vented crawl space in summer. Hot, humid air enters through the vent and condenses on ducts and framing cooled by the air conditioning above; moisture also evaporates from the soil.

2. What a closed crawl space actually needs

A closed crawl space is not plastic on the ground and closed vents. It is a system of three components, each addressing one source of moisture:

1. **Air sealing** keeps humid outdoor air out.
2. **A ground vapor barrier** slows evaporation from the soil.
3. **A drying mechanism**, conditioned supply air or a dehumidifier, removes the moisture that remains.

Where groundwater enters, drainage is corrected first. Water intrusion and humidity are different problems, and a liner does not fix the first one.

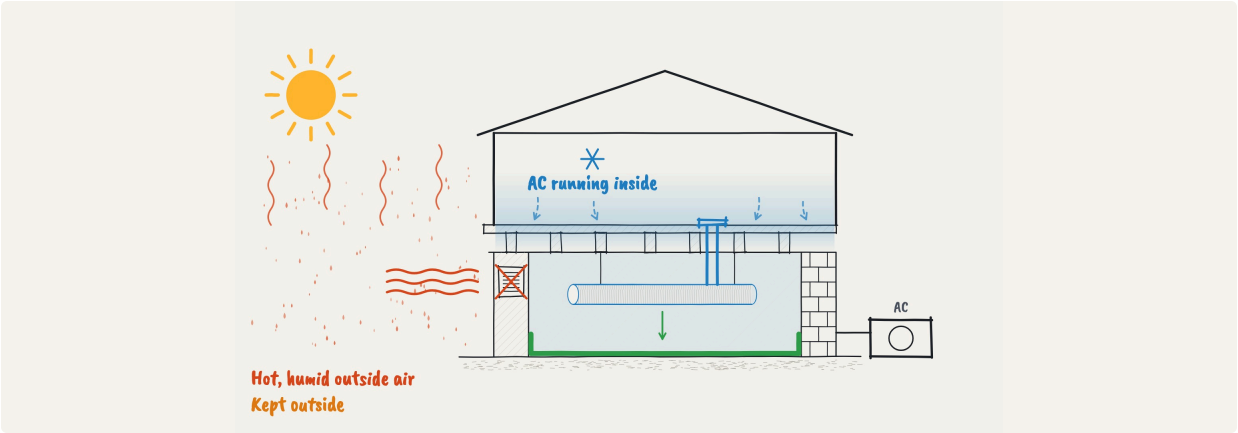


Figure 2. The closed crawl space system: vents sealed, a ground vapor barrier, and dry air supplied to the crawl space.

3. What the ground vapor barrier does

The ground barrier's job is to reduce the rate of evaporation from the soil. The goal is not to dry every grain of dirt or stop every molecule of vapor; it is to reduce the daily moisture load enough that the drying mechanism can keep the wood dry.

A durable 12 mil woven barrier, overlapped and pinned over 1,500 square feet of soil, covers nearly all of the exposed ground. Some vapor may move around untaped seams and edges. The questions are how much, whether it measurably loads the dehumidifier or supply air, and whether it raises wood moisture. A claim that tape is necessary should come with those measurements. If the ground stays wet, tape is not the solution; drainage is.

4. The Advanced Energy Phase III findings

Advanced Energy's DOE-funded field study in North Carolina compared wall-vented crawl spaces with several closed crawl space designs [1]. In Phase III, three of the vented control homes were converted to closed crawl spaces by sealing the foundation vents and adding a crawl space supply duct, without sealing the existing ground vapor retarder and without any wall vapor retarder. The report describes the result:

> *"Meanwhile, the three control homes that were converted to the experiment 3 group at the end of June, 2004 (by sealing the foundation vent openings and installing a crawl space supply duct without sealing the ground vapor retarder or installing any wall vapor retarder material) quickly exhibited performance similar to that of the other closed crawl space designs."*
>
> Advanced Energy, Final Report to DOE, June 2005, p. 88 [1]

Structural wood moisture

Figure 3 compares the two closed designs that differ only in how the plastic was installed. Both had R-19 floor insulation. One had a sealed ground liner continuing up the foundation walls; the other had overlapped, staked ground sheets with no seams sealed and no wall liner.

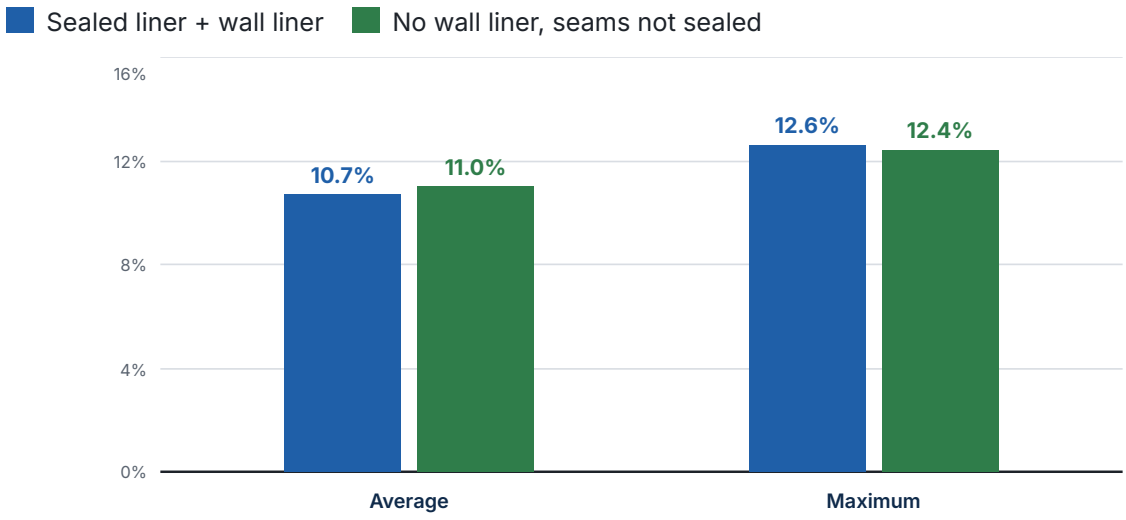


Figure 3. Structural wood moisture content in Phase III closed crawl spaces, redrawn from Figure 50 of the Advanced Energy report (p. 88). Single reading, early August 2004. Values read from the published bar chart, accurate to about 0.1%.

The unsealed group's average was about 0.3 points higher; its maximum was about 0.2 points lower. Neither group came near the 16% level at which the author investigates, let alone the levels associated with decay. The study's own conclusion is that the closed designs "almost eliminate the risk of rot in the crawl spaces not due to plumbing leaks" [1].

> **What the data does and does not show.** The Phase III comparison is three homes per group and one wood moisture reading. The unsealed group maintained average daily relative humidity below 70% with dew points just above 60°F; the sealed groups stayed below 60% RH with dew points between 55 and 60°F [1]. The study used 6-mil polyethylene, overlapped and staked, not 12 mil woven material.
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> So the study does not prove that sealing never helps. It shows that more sealing was not necessary to achieve comparable wood moisture in those homes. That is a different claim from "every crawl space needs the complete package," and it is the claim the industry would need to support with measurements of its own.

5. Wrapped piers, covered walls and service access

A 20-inch coastal crawl space is not a finished basement. It holds block walls, masonry piers, ductwork and plumbing, with very little room to move. If a foundation wall gets slightly damp after rain, that moisture can evaporate into the crawl space; the question is whether it is enough to affect the wood. If water is actually coming through the wall, the repair is drainage. Covering the wall hides the evidence.

Concrete block is not smooth. Mortar joints, pier ridges, penetrations, tape joints and fasteners make a lasting seal difficult. The author has seen pier wraps with gaps large enough to put a hand behind, and has never inspected a fully encapsulated crawl space with no gaps anywhere. As these systems age, connections loosen, rodents chew through the plastic, and tradespeople disturb it during repairs.

Covered walls make termite tubes, cracks, rodent entry points and water intrusion harder to find. The crawl space is a service space; plumbing, HVAC, electrical, pest and drainage work will all eventually need access. Wherever the design allows, access to the foundation should be preserved.



Figure 4. Left: a wrapped block pier; the tape bridges the ridged block ends and leaves open voids at the corner. Right: termite shelter tubes on a block foundation wall. A wall liner would hide them from inspection.

What experienced professionals say

Over roughly twenty years, the author has discussed crawl space moisture control with more than a hundred home inspectors, termite professionals, building officials and experienced contractors in coastal Virginia. They agree that moisture must be controlled. In those conversations, none said the additional plastic was necessary, and none would install sealed liners, wrapped piers and covered foundation walls under their own homes. Simple ground barriers, sealed vents, proper drying and drainage where needed have worked in this region for decades.

The exception: radon and soil gases

Where testing identifies a soil-gas problem such as radon, a properly sealed membrane with sub-membrane depressurization may be necessary. That is a specific mitigation design, justified by a test result, not a general argument for wrapping every coastal crawl space in plastic.

6. Cost

For a typical 1,500-square-foot coastal crawl space with about 20 inches of clearance, approximate installed costs in the Hampton Roads market are:

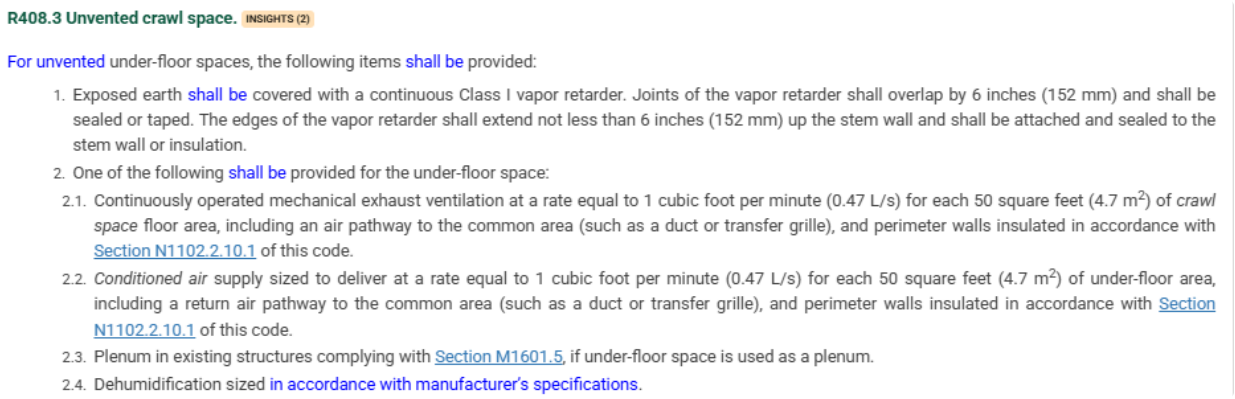
System	Approximate cost
Pinned 12 mil woven ground vapor barrier (Patriot)	**$2,800**
Sealed liner: taped seams, covered walls, wrapped piers	**$7,500**
Larger encapsulation liner plus wall insulation	**$12,000**
Complete package: drainage, rodent exclusion, insulation, mechanical drying	**$25,000–$30,000**

The sealed liner costs about **$4,700** more than the pinned barrier, nearly three times the price for the liner work alone. Much of that difference is labor: taping seams and wrapping piers while working on one's stomach under ductwork and plumbing is slow. These figures should not be compared with tall mountain crawl spaces where installers can move freely.

Both systems can be damaged. Rodents may contaminate them, and drainage repairs may require removing them. A pinned barrier is cheaper to pull back, repair or replace when the plumber or drainage crew comes through.

7. New construction code versus repair

IRC Section R408.3 sets prescriptive requirements for unvented crawl spaces in new construction. For exposed earth, it calls for a continuous Class I vapor retarder with joints overlapped 6 inches and sealed or taped, extending at least 6 inches up the stem wall, along with one of several listed drying methods [2].



R408.3 Unvented crawl space. INSIGHTS (2)

For unvented under-floor spaces, the following items shall be provided:

1. Exposed earth shall be covered with a continuous Class I vapor retarder. Joints of the vapor retarder shall overlap by 6 inches (152 mm) and shall be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (152 mm) up the stem wall and shall be attached and sealed to the stem wall or insulation.
2. One of the following shall be provided for the under-floor space:
   - 2.1. Continuously operated mechanical exhaust ventilation at a rate equal to 1 cubic foot per minute (0.47 L/s) for each 50 square feet (4.7 m^2) of *crawl space* floor area, including an air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.10.1 of this code.
   - 2.2. *Conditioned air* supply sized to deliver at a rate equal to 1 cubic foot per minute (0.47 L/s) for each 50 square feet (4.7 m^2) of under-floor area, including a return air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.10.1 of this code.
   - 2.3. Plenum in existing structures complying with Section M1601.5, if under-floor space is used as a plenum.
   - 2.4. Dehumidification sized in accordance with manufacturer's specifications.

Figure 5. IRC Section R408.3, Unvented crawl space [2].

Repairing an existing home is a different activity, governed by its own provisions for existing buildings. The first step is to determine what work is being done and why; that determines how the work is classified. A new-construction assembly is not automatically the repair prescription.

Consider a slightly musty basement. No one would excavate to the footings, remove the slab, install a new drainage system and spend $160,000 because that is how a new basement would be built. The reasonable course is to diagnose the moisture source and start with the repair most likely to correct it. Crawl spaces should be treated the same way.

8. Recommended approach for existing coastal crawl spaces

For a typical low crawl space in coastal Virginia, the author recommends:

1. Clean contaminated framing.
2. Repair or replace musty or failing ductwork.
3. Correct known drainage problems.
4. Exclude rodents thoroughly, including proper screening at entry points.
5. Seal exterior air openings.
6. Install a durable, overlapped and pinned ground vapor barrier.
7. Provide conditioned supply air or a properly sized dehumidifier.



Figure 6. Left: a finished Patriot crawl space with a pinned ground barrier, foam-sealed vents and exposed foundation walls. Right: a structural wood moisture reading of 10.5%.

Monitoring targets

After installation, monitor temperature, relative humidity, dew point and structural wood moisture. In the author's crawl spaces:

Wood moisture	Meaning
10–11%	Typical average
12–13%	Target summer readings
16%	Upper limit; investigate

If a new problem appears, diagnose and correct it. Keep the system accessible and easy to change.

9. Questions for every component

Before signing an encapsulation contract, a homeowner, inspector or building official should ask two questions of each component, not of the system as a whole:

1. What does this component cost?
2. What happens to the wood if it is left out?

Whether the recommendation comes from a salesperson, an engineer, a building scientist or a code official, the standard is the same: show the measurable benefit. The objective is dry structural wood, maintained in a space that can still be inspected and serviced. Every component should earn its place.

The author welcomes field data that tests these conclusions, particularly measurements comparing sealed and overlapped ground barriers in low coastal crawl spaces with sealed vents, adequate drying and corrected drainage.

References

[1] Advanced Energy. 2005. A *Field Study Comparison of the Energy and Moisture Performance Characteristics of Ventilated Versus Sealed Crawl Spaces in the South.* Final report to the U.S. Department of Energy. Raleigh, NC. p. 88 and Figure 50; conclusions. osti.gov/biblio/850459

[2] International Code Council. *International Residential Code*, Section R408.3, Unvented Crawl Space. codes.iccsafe.org

[3] U.S. Department of Energy, Building America. *Unvented Conditioned Crawlspaces: Building America Top Innovation.* energy.gov

About the author



Robbie McCarty is the owner of Patriot Crawl Space Repairs in Hampton Roads, Virginia. He personally inspects more than 600 crawl spaces a year and has been involved in building, renovating, inspecting and selling homes across roughly three decades in Virginia construction and real estate. He holds a Virginia Class A contractor's license, a master plumber license, a licensed pest control operator credential and MICRO certification as a mold remediation contractor.

His company specializes in structural repair, mold remediation and moisture control in the hot, humid coastal Southeast. His Crawl Space Science video series and technical papers document what works, and what does not, in this climate.

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