

Getting Started

Both scientific research projects and real-world installations demonstrate that properly closed crawl spaces can provide much better moisture control than conventional, wall-vented crawl spaces in temperate-humid climates. Homes with closed crawl spaces (often also called “sealed,” “unvented” or “conditioned” crawl spaces) also can save significantly on energy when compared to homes with wall-vented crawl spaces.

This sheet summarizes key issues that builders, code officials and consumers should keep in mind when deciding how to design or install closed crawl spaces in new construction.

The second sheet provides two sample designs that have been field-tested and extensively monitored.

For more details and information on improving wall-vented crawl spaces in existing homes, visit www.crawlspaces.org.

DESIGNING CLOSED CRAWL SPACES

The recommended components of a good design fall into six major categories:

Moisture Management

- A roof runoff system to direct water away from the house
- Site grading and landscaping that directs ground surface water away from the house
- Foundation drains and foundation damp-proofing or water-proofing to protect the structure from sub-surface water
- Air sealing of the access door, perimeter wall and perimeter framing to prevent the entry of moisture-laden outside air and to separate the crawl space from areas under porches or decks
- An access door that is protected from roof runoff, at least 4" higher than the exterior soil grade and made of a non-corroding material, especially in coastal communities
- A fully sealed vapor retarder on the floor and perimeter walls to reduce evaporation of water into the crawl space
- Appliance discharge pipes and exhausts from kitchens, bathrooms and clothes dryers that terminate outside the crawl space
- A mechanical drying system to reduce humidity (for example, a supply of conditioned air or a dehumidifier)
- Drains with backflow valves or sump pumps to remove liquid water from the crawl space if necessary
- Flood vents that minimize standby air leakage, when required

Pest Control

- A termite inspection gap at the top of the perimeter wall to facilitate detection
- Batt insulation in the band joist area of wall-insulated closed crawl spaces to facilitate inspection or treatment

Combustion Safety

- Specification of direct-vent (“two-pipe”) combustion appliances to ensure adequate combustion air for fuel-fired appliances, if applicable. Some manufacturers have direct-vent cabinets for use with non-direct-vent models. Alternate means of providing combustion air must be approved by the appliance manufacturer and local residential code requirements.
- For homes on slabs, basements or crawl spaces, specification of carbon monoxide monitors or alarms if the structure has an attached garage or any combustion appliances
- For homes on basements or crawl spaces, optional specification of an appropriately placed raw-gas leak alarm if fuel-fired appliances or fuel lines are in the home

Fire Safety

- Air sealing of all penetrations in the sub-floor with non-porous materials
- Documentation of fire-rating to allow installation of exposed foam insulation without a thermal barrier, if applicable
- Documentation of fire-rating to allow installation of exposed facing or backing materials on batt insulation, if applicable

Thermal Insulation

- Insulation at the sub-floor or at the perimeter wall to provide the R-value required by the local residential code. Note that perimeter insulation may be located on the interior surface, exterior surface or inside the perimeter wall, or the perimeter wall itself may provide the required R-value
- Insulation at the sub-floor installed without gaps or compression and in full contact with the sub-floor to achieve nominal R-value
- Non-porous insulation if the perimeter wall is insulated
- Insulation on the crawl space access(es) of minimum R-2

Radon Control

- In areas where radon is a risk or where the local residential code requires control of radon or other soil gases, houses with closed crawl space foundations can be tested, monitored and, if necessary, mitigated with the same techniques used for houses with a slab or basement foundation in the same region.
- The U.S. Environmental Protection Agency and the Surgeon General recommend testing all homes for radon

INSTALLING CLOSED CRAWL SPACES

Choosing a design for a closed crawl space goes hand-in-hand with the first steps required to install the closed crawl space: coordinating with code officials to ensure that your design meets local residential code requirements and obtaining the required permits. At the time of this writing, the North Carolina Building Code Council has adopted and the state of North Carolina has approved new code language governing both wall-vented and closed crawl spaces. This new code is available for reference as of January 1, 2005, as an alternate to the existing printed code, and the new code will be enforced in 2006 with the release of the updated North Carolina Residential Code. In some cases, local code officials may require or accept a stamped letter of approval from a registered professional engineer as an alternate path for permitting and inspection.

Quality installers ensure that their employees are trained in the use of the tools and materials required to install their closed crawl space system and generally provide and/or require the use of respirators and protective clothing for the comfort and safety of their employees. Quality installers of closed crawl spaces will have documented processes for coordinating with the general contractor and other building trades to ensure proper scheduling and to reduce the risk of damage to the closed crawl space system during construction. They also will explain any impact on pricing or scheduling of variable factors like the number of piers in a crawl space, height above or below grade or complexity of the foundation footprint.

Recommended Strategies for Avoiding Problems

Quality installers of closed crawl spaces know that managing moisture during the process of construction is critical for success and will use several strategies to avoid problems:

- Grading the crawl space floor surface to one or more low spots and installing a drain or other method to remove water that enters the crawl space prior to dry-in
- Grading around the foundation as soon as possible to reduce the amount of roof runoff or ground surface water that enters the crawl space
- Minimizing the amount of rainwater that can enter the crawl space
- Covering the crawl space floor with a temporary vapor retarder by the time the structure is dried-in. This temporary cover must be removed before installation of the finished ground vapor retarder.
- Puncturing holes at low spots in the temporary ground vapor retarder (if the ground is not saturated) to allow small puddles to drain into the ground
- Closing the access door(s) and running a dehumidifier to remove accumulated moisture after the structure is dried-in
- Coordinating with the construction site crew to ensure that the crawl space door is closed as much as possible, that all drains remain unblocked and that any dehumidifiers have a power source, run long enough to provide the necessary drying and are protected from theft

Additional Recommendations

- Coordinate with your pest management professional to ensure that the closed crawl space system does not interfere with their treatment or affect their warranty, if applicable
- Mechanically fasten the liner material to the perimeter wall in addition to sealing it to the wall. Adhesives, sealants or tapes alone may be insufficient to support the material.
- Use duct mastic with embedded fiberglass mesh tape to seal seams in crawl space vapor retarder materials. If tapes or sealants are to be used, ensure that the product is accepted for use by the manufacturer of the material and will provide long-term performance. Regardless of the method, a quality installer will have a process in place to ensure proper installation.
- Protect 6-mil un-reinforced polyethylene ground vapor retarders to avoid damage in areas that will be accessed for servicing of mechanical equipment. Thicker, reinforced polyethylene materials are more durable.

Quality Assurance Options

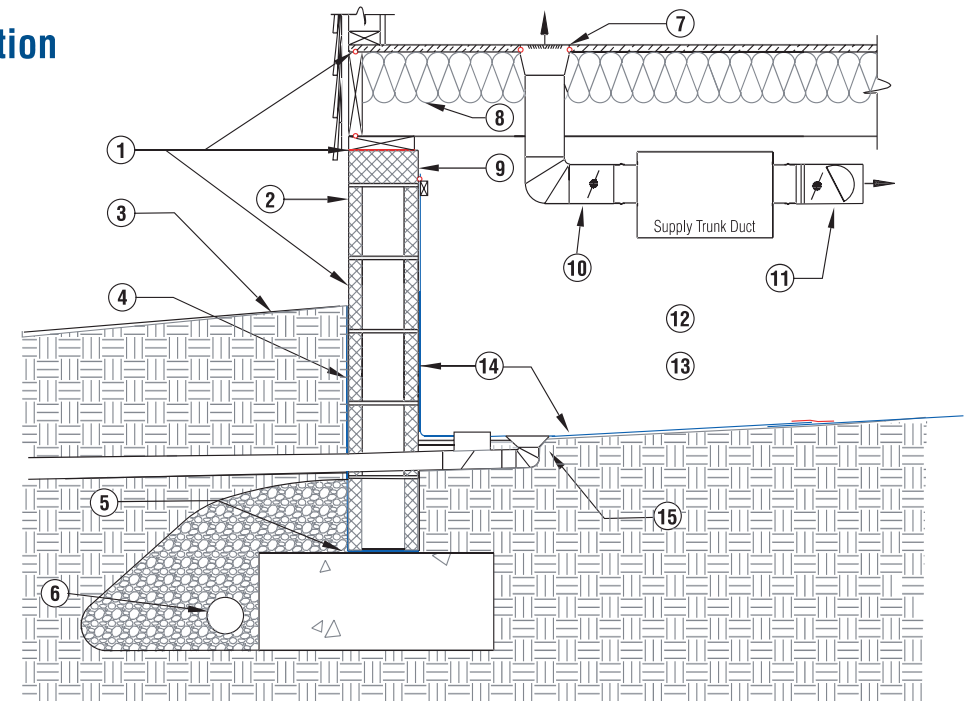
Experienced installers care about the long-term performance of their system and will usually offer one or more of the following quality assurance options with their closed crawl space system:

- A monitoring system to inform the homeowner of relative humidity levels in the crawl space
- A water alarm to inform the homeowner of a buildup of liquid water in the crawl space
- A posted sign informing anyone entering the crawl space of the system components maintaining the integrity of the system
- A repair kit for fixing small amounts of damage to the vapor retarder after the house is occupied
- An annual monitoring service to replace batteries in monitoring systems and check that the crawl space system is in good working order. This may include measurements of wood moisture content or air tightness, or download and analysis of data logging equipment
- A guarantee that relative humidity will be maintained below an agreed-upon target (typically 70% or lower) over specified periods of time with exceptions for water leaks or intrusion outside their control
- References to independent third-parties for quality assurance

DESIGN SAMPLE 1

A closed crawl space with supply air and floor insulation

1. Seal exterior wall penetrations and mating surfaces at top and bottom of sill plate and at top and bottom of band joist. Crawl space access panel(s) or door(s) must be air-sealed.
2. No open foundation vents are allowed in exterior walls. Openings to ventilated porch foundations must be air-sealed with an access panel or permanent materials. Install flood vents per local residential code where required.
3. Slope finished grade away from building per local residential code or for 6-inch drop over 10 feet. Provide a method to transport roof runoff away from the house. Gutters and downspouts are one such method.
4. Dampproof or waterproof the exterior wall surface when the crawl space floor is below exterior grade.
5. It is not necessary to provide a capillary break between the footings and foundation walls or interior columns.
6. Provide foundation drain to daylight per local residential code requirements.
7. Seal all plumbing, electrical, duct, cable, and other penetrations through the sub-floor with fire-stop materials and sealants. Fiberglass or rockwool insulation alone are not sufficient.
8. Insulate floor joist cavities. Place insulation in full contact with the sub-floor and ensure that it is secured in place. Use R-value required by local residential code and install without gaps, voids, or compression.
9. Leave a minimum 3" termite inspection gap between the top of the wall vapor retarder and the top of the masonry wall. Seal the top of the vapor retarder to the wall with duct mastic or equivalent sealant. Optionally, apply a light colored paint or coating over the inspection gap to improve inspectability by pest control professionals.
10. Air seal all heating and cooling ductwork with a mastic system. Install all ductwork located in the crawl space with R-value per local code requirement.
11. Control moisture vapor in the crawl space with supply air from the house air-conditioning system. Set supply air volume per local residential code requirement. Adjust as needed to control relative humidity in crawl space to desired level. Provide a backflow damper and either a balancing damper or constant airflow regulator to control airflow. Multiple supply vents may be used to achieve the desired airflow and/or desired distribution of air. No return air vent is allowed in the crawl space.
12. Terminate water heater drains, temperature/pressure relief pipes, and A/C condensate drains to outdoors or to an interior pump that discharges to a drain or outdoors. Terminate all kitchen, bathroom and clothes dryer vents to outdoors.
13. Any fuel-fired furnaces, water heaters, or other appliance in a closed crawl space should be of a "direct vent" or "two pipe" design, meaning that all air for combustion is piped directly from outside to the appliance and all



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combustion exhaust gases are piped directly from the appliance to outside.

14. Cover 100% of the crawl space floor with a minimum 6-mil vapor retarder. Install vapor retarder material on the inside wall surfaces, and mechanically fasten and seal it to the top of the walls, leaving the required inspection gap. Extend the material up the interior columns at least 4 inches above the crawl space floor. Seal all seams and edges with fiberglass mesh tape and mastic or equivalent. Mechanically secure the vapor retarder to the ground as necessary.
15. Grade the crawl space floor to one or more low points. Provide crawl space drain(s) or sump pump(s) at lowest point(s). Slope drains to daylight and include an accessible backflow valve and 1/4-inch rodent screening. Gutter drains and foundation drains (interior or exterior) must not be connected to the crawl space drain.

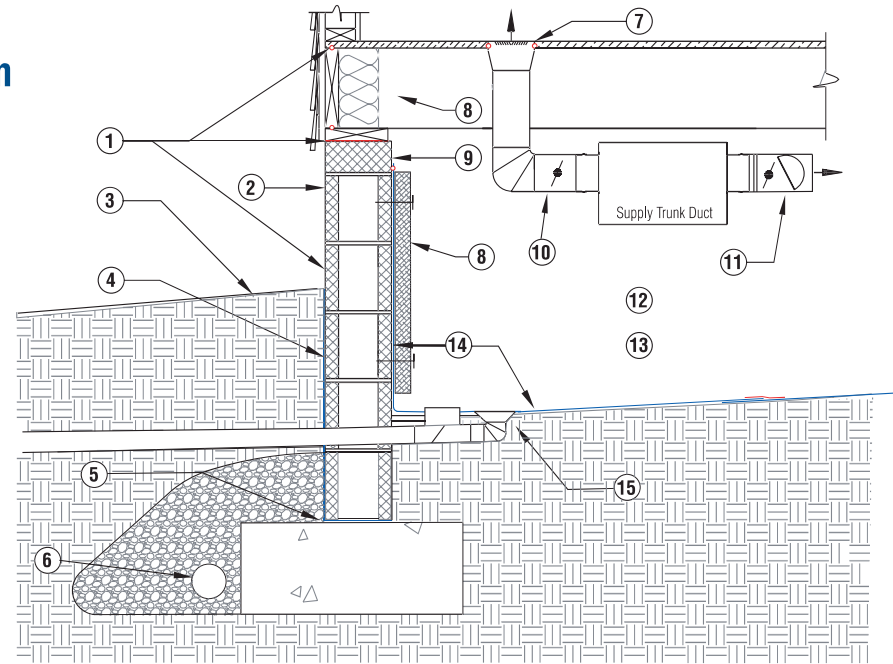
DESIGN SAMPLE 2

A closed crawl space with supply air and wall insulation

1. Seal exterior wall penetrations and mating surfaces at top and bottom of sill plate and at top and bottom of band joist. Crawl space access panel(s) or door(s) must be air-sealed.
2. No open foundation vents are allowed in exterior walls. Openings to ventilated porch foundations must be air-sealed with an access panel or permanent materials. Install flood vents per local residential code where required.
3. Slope finished grade away from building per local residential code or for 6-inch drop over 10 feet. Provide a method to transport roof runoff away from the house. Gutters and downspouts are one such method.
4. Dampproof or waterproof the exterior wall surface when the crawl space floor is below exterior grade.
5. It is not necessary to provide a capillary break between the footings and foundation walls or interior columns.
6. Provide foundation drain to daylight per local residential code requirements.
7. Seal all plumbing, electrical, duct, cable, and other penetrations through the sub-floor with fire-stop materials and sealants. Fiberglass or rockwool insulation alone are not sufficient.
8. Insulate the crawl space wall over the wall vapor retarder material with rigid foam or other non-porous insulation material. Leave a minimum 3" termite inspection gap between the top of the wall insulation and the top of the masonry wall. Leave a 3" wicking gap between the bottom of the

wall insulation and the crawl space floor surface. Obtain R-value from local residential code. Ensure that the insulation complies with local residential code requirements for installation without a thermal barrier or ignition barrier. Insulate the band joist with batt insulation to facilitate removal and reinsertion during pest control inspections. Ensure that batt facings comply with local fire requirements.

9. Leave a minimum 3" termite inspection gap between the top of the wall vapor retarder and the top of the masonry wall. Seal the top of the vapor retarder to the wall with duct mastic or equivalent sealant. Optionally, apply a light colored paint or coating over the inspection gap to improve inspectability by pest control professionals.
10. Air seal all heating and cooling ductwork with a mastic system. Install all ductwork located in the crawl space with R-value per local code requirement.
11. Control moisture vapor in the crawl space with supply air from the house air-conditioning system. Set supply air volume per local residential code requirement. Adjust as needed to control relative humidity in crawl space to desired level. Provide a backflow damper and either a balancing damper or constant airflow regulator to control airflow. Multiple supply vents may be used to achieve the desired airflow and/or desired distribution of air. No return air vent is allowed in the crawl space.
12. Terminate water heater drains, temperature/pressure relief pipes, and



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- A/C condensate drains to outdoors or to an interior pump that discharges to a drain or outdoors. Terminate all kitchen, bathroom, and clothes dryer vents to outdoors.
13. Any fuel-fired furnaces, water heaters, or other appliance in a closed crawl space should be of a "direct vent" or "two pipe" design, meaning that all air for combustion is piped directly from outside to the appliance and all combustion exhaust gases are piped directly from the appliance to outside.
 14. Cover 100% of the crawl space floor with a minimum 6-mil vapor retarder. Install vapor retarder material on the inside wall surfaces, and mechanically fasten and seal it to the top of the walls, leaving the required inspection gap. Extend the

- material up the interior columns at least 4 inches above the crawl space floor. Seal all seams and edges with fiberglass mesh tape and mastic or equivalent. Mechanically secure the vapor retarder to the ground as necessary.
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