**STATE OF WISCONSIN**
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**UNIFORM DWELLING CODE COUNCIL MEETING**
**Room 121B, 1400 East Washington Avenue, Madison**
**Contact: Jeff Grothman (608) 266-2112**
**April 29, 2015**

*The following agenda describes the issues that the Council plans to consider at the meeting. At the time of the meeting, items may be removed from the agenda. Please consult the resulting meeting minutes for a description of the recommendations of the Council.*

**AGENDA**

**9:00 A.M.**

**CALL TO ORDER – ROLL CALL**

**A) Adoption of Agenda (1)**

**B) Approval of Minutes of March 10, 2015 (2)**

**C) Department Update**

1. **UDC Update Status**
2. **UDC Deck Rules Status**
3. **AB 121 – Camping Units (3-6)**

**D) Discussion Regarding Email Notification for 320.10 (4) (a) 1. and 320.10 (4) (a) 2 (7-8)**

**E) Discussion of Crawlspace Ventilation (9-47)**

**F) Discussion of Windows Above Garages**

**G) Discussion of Fire Separation at Garages Where One Structure is Two Stories**

**H) Public Comments**

**I) Future Business**

**J) Adjournment**

**UNIFORM DWELLING COUNCIL**
**MEETING MINUTES**
**March 10, 2015**

**PRESENT:** Amy Bliss, Michael Coello, Abe Degnan *(excused at 11:40 a.m.)*, Steven Gryboski, Jesse Jerabek, Mike Marthaler, Scott Satula, Mary Schroeder *(arrived at 9:26 a.m.)*, Brian Wert *(arrived at 9:06 a.m. via GoToMeeting)*

**EXCUSED:** David Dolan-Wallace, Peter Krabbe

**STAFF:** Jeff Grothman, Policy Director; Dan Smith, Rules Coordinator; Steve Dobratz, Integrated Services Section Chief; Duane Hubeler, UDC Engineering Consultant; and Taylor Thompson, Bureau Assistant

## CALL TO ORDER

Michael Coello, Chair, called the meeting to order at 9:04 a.m. A quorum of seven (7) members was confirmed.

## ADOPTION OF AGENDA

**MOTION:** Jesse Jerabek moved, seconded by Amy Bliss, to adopt the agenda as published. Motion carried unanimously.

## APPROVAL OF MINUTES

**MOTION:** Mike Marthaler moved, seconded by Abe Degnan, to approve the minutes of February 13 as published. Motion carried unanimously.

## FINAL WALK-THROUGH OF PROPOSED DRAFT RULES BASED ON THE JULY 2014 DWELLING CODE COUNCIL REPORT

**MOTION:** Jesse Jerabek moved, seconded by Brian Wert, to approve draft rules with all recommended changes and send to the Department. Motion carried unanimously.

## REVIEW OF PRESCRIPTIVE DECK STANDARDS DRAFT RULES

**MOTION:** Steven Gryboski moved, seconded by Amy Bliss, to authorize Jesse Jerabek to engineer and draw a third option to Figure 30. Motion carried unanimously.

**MOTION:** Mary Schroeder moved, seconded by Steve Gryboski, to approve the proposed draft deck rules with all recommended changes and send to the Department. Motion carried unanimously.

## ADJOURNMENT

**MOTION:** Scott Satula moved, seconded by Amy Bliss, to adjourn the meeting. Motion carried unanimously.

The meeting adjourned at 1:41 p.m.

DRAFT

State of Wisconsin
2015 - 2016 LEGISLATURE

LRB–0157/1
RNK:cjs:rs

# 2015 ASSEMBLY BILL 121

March 27, 2015 – Introduced by Representatives RIPP, BALLWEG, BERNIER, CZAJA, EDMING, HUTTON, JACQUE, KITCHENS, KLEEFISCH, KRUG, MURPHY, MURSAU and THIESFELDT, cosponsored by Senators OLSEN, COWLES, HARSDORF, MARKLEIN, TIFFANY and BEWLEY. Referred to Committee on Housing and Real Estate.

AN ACT ***to renumber and amend*** 145.02 (2); ***to amend*** 101.63 (1) (intro.) and 101.82 (1); and ***to create*** 145.02 (2) (b) of the statutes; **relating to:** standards for the construction and inspection of camping units; for installing, repairing, and maintaining electrical wiring in camping units; and for plumbing in camping units; providing an exemption from emergency rule procedures; and granting rule–making authority.

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***Analysis by the Legislative Reference Bureau***

Under current law, any one–family or two–family dwelling for which initial construction began on or after December 1, 1978, must comply with the one–family and two–family dwelling code (dwelling code). Under current law, the Department of Safety and Professional Services (DSPS) promulgates rules for this code which includes standards for heating, ventilation, plumbing, electricity, and other systems. One–family and two–family dwellings for which initial construction began before that date are not covered by this code but are subject to the state electrical and plumbing codes.

This bill provides that DSPS's rules for the dwelling code, the electrical code, and the plumbing code must include separate standards that apply only to camping units that are set in a fixed location in a campground for which the Department of Health Services has issued a permit, that contain a sleeping place, and that are used for seasonal overnight camping. The bill provides that if DSPS has appointed a

committee to advise DSPS on rule making with respect to private on–site wastewater treatment systems, DSPS must promulgate the separate standards under the plumbing code in consultation with that committee.

For further information see the ***state*** fiscal estimate, which will be printed as an appendix to this bill.

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***The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:***

**SECTION 1.** 101.63 (1) (intro.) of the statutes is amended to read:

101.63 **(1)** (intro.) Adopt rules which establish standards for the construction and inspection of one– and 2–family dwellings and components thereof. <u>The rules shall include separate standards, established in consultation with the dwelling code council, that apply only to the construction and inspection of camping units that are set in a fixed location in a campground for which a permit is issued under s. 254.47, that contain a sleeping place, and that are used for seasonal overnight camping.</u> Where feasible, the standards used shall be those nationally recognized and shall apply to the dwelling and to its electrical, heating, ventilating, air conditioning and other systems, including plumbing, as defined in s. 145.01 (10). No set of rules may be adopted which has not taken into account the conservation of energy in construction and maintenance of dwellings and the costs of specific code provisions to home buyers in relationship to the benefits derived from the provisions. Rules promulgated under this subsection do not apply to a bed and breakfast establishment, as defined under s. 254.61 (1), except that the rules apply to all of the following:

**SECTION 2.** 101.82 (1) of the statutes is amended to read:

101.82 **(1)** Promulgate by rule a state electrical wiring code that establishes standards for installing, repairing, and maintaining electrical wiring. <u>The rules</u>

shall include separate standards, established in consultation with the dwelling code council, that apply only to electrical wiring in camping units that are set in a fixed location in a campground for which a permit is issued under s. 254.47, that contain a sleeping place, and that are used for seasonal overnight camping. Where feasible, the rules shall reflect nationally recognized standards.

**SECTION 3.** 145.02 (2) of the statutes is renumbered 145.02 (2) (a) and amended to read:

145.02 **(2)** (a) The department shall have general supervision of all such plumbing and shall after public hearing prescribe and publish and enforce reasonable standards therefor which shall be uniform and of statewide concern so far as practicable. Any employee designated by the department may act for the department in holding ~~such~~ the public hearing required under this subsection. To the extent that the historic building code applies to the subject matter of these standards, the standards do not apply to a qualified historic building if the owner elects to be subject to s. 101.121.

**SECTION 4.** 145.02 (2) (b) of the statutes is created to read:

145.02 **(2)** (b) The department shall promulgate rules that establish separate plumbing standards applicable only to camping units that are set in a fixed location in a campground for which a permit is issued under s. 254.47, that contain a sleeping place, and that are used for seasonal overnight camping. If the department has appointed a committee under s. 227.13 to advise the department on rule making with respect to private on–site wastewater treatment systems, the department shall promulgate the rules required under this paragraph in consultation with that committee.

**SECTION 5. Nonstatutory provisions.**

(1) The department of safety and professional services shall use the procedure under section 227.24 of the statutes to promulgate the rules under sections 101.63 (1) (intro.), 101.82 (1), and 145.02 (2) (b) of the statutes, as affected by this act. Notwithstanding section 227.24 (1) (c) and (2) of the statutes, emergency rules promulgated under this subsection remain in effect until July 1, 2018, or the date on which permanent rules take effect, whichever is sooner. Notwithstanding section 227.24 (1) (a) and (3) of the statutes, the department of safety and professional services is not required to provide evidence that promulgating a rule under this subsection as an emergency rule is necessary for the preservation of the public peace, health, safety, or welfare and is not required to provide a finding of emergency for a rule promulgated under this subsection. Notwithstanding section 227.24 (1) (e) 1d. and 1g. of the statutes, the department of safety and professional services is not required to prepare a statement of the scope of the rules promulgated under this subsection or present the rules to the governor for approval.

**(END)**

(c) *Private onsite wastewater treatment systems.* Pursuant to s. 145.195, Stats., if the proposed construction requires connection to a private onsite wastewater treatment system, a Wisconsin uniform building permit may not be issued unless conformance with s. SPS 383.25 (2) has first been determined.

**Note:** See appendix for a reprint of s. SPS 383.25 (2).

(d) *Posting of permit.* 1. The Wisconsin uniform building permit shall be posted in a conspicuous place at the dwelling site.

2. The Wisconsin uniform building permit seal shall be affixed to the posted permit or to the Wisconsin uniform building permit application. The permit seal number shall appear on both documents.

**(10)** DISAPPROVAL OF PLANS AND DENIAL OF PERMITS. (a) *General.* Approval shall be denied if the municipality or authorized UDC inspection agency administering and enforcing this code determines that the Wisconsin uniform building permit application or the plans do not substantially conform to the provisions of this code and other legal requirements.

(b) *Denial of application.* A copy of the denied application, accompanied by a written statement specifying the reasons for denial, shall be sent to the applicant and to the owner as specified on the Wisconsin uniform building permit application.

(c) *Stamping of plans.* 1. Plans which do not substantially conform to the provisions of the code shall be stamped "not approved."

2. One copy shall be returned to the person applying for the Wisconsin uniform building permit and one copy shall be retained by the municipality or authorized UDC inspection agency administering and enforcing the code.

(d) *Appeals.* The applicant may appeal a denial of the application in accordance with the procedure outlined in s. SPS 320.21.

**(11)** TIME-SPAN FOR APPROVAL OR DENIAL. Action to approve or deny a uniform building permit application shall be completed within 10 business days of receipt of all forms, fees, plans and documents required to process the application, and completion of other local prerequisite permitting requirements.

**History:** Cr. Register, November, 1979, No. 287, eff. 6−1−80; r. and recr. (7), Register, February, 1985, No. 350, eff. 3−1−85; am. (4) (b) and (5) (b) 1., Register, January, 1989, No. 397, eff. 2−1−89; am. (3) (a) and (4) (a) 2., Register, March, 1992, No. 435, eff. 4−1−92; am. (4) (a) 1., (5) (a), (b) 2. and (6) (intro.), Register, September, 1992, No. 441, eff. 12−1−92; renum. (2) to be (2) (a) and am., am. (3) and (7), cr. (2) (b), (3) (c), Register, November, 1995, No. 479, eff. 12−1−95; r. and recr. (5) (b) 1., Register, October, 1996, No. 490, eff. 11−1−96; am. (4) (a) 1. a. and (b), r. and recr. (4) (a) 1. b., r. (4) (a) 1. c. and d., Register, February, 1997, No. 494, eff. 3−1−97; am. (5) (a), Register, March, 1998, No. 507, eff. 4−1−98; cr. (5) (b) 1. c. and d., Register, January, 1999, No. 517, eff. 2−1−99; cr. (5) (b) 3., Register, April, 2000, No. 532, eff. 7−1−00; correction in (5) (b) 3. made under s. 13.93 (2m) (b) 7., Stats; correction in (5) (b) 3. made under s. 13.93 (2m) (b) 7., Stats., Register, March, 2001, No. 543; CR 00−159: am. (1), (2), (4) (intro.), (5) (a), (5) (b) 2. and (c), (6) (intro.) and (b), r. and recr. (3), (5) (b) 1. d., cr. (8), Register September 2001 No. 549 eff. 12−1−01; correction in (5) (b) 1. b. made under s. 13.93 (2m) (b) 7., Stats., Register May 2003 No. 569; CR 03−097: am. (1), (2) (a), r. (2) (a) 2., (b), (3) (b), and (8), cr. (2) (b), renum. (3) (c) to be (3) (b) and am, Register November 2004 No. 587, eff. 1−1−05; CR 05−113: r. and recr. (4) (a) 1., renum. (4) (b) and (c) to be (4) (c) and (d) and am. (4) (c), cr. (4) (b) Register December 2006 No. 612, eff. 4−1−07; CR 07−007: r. and recr. (2) (b) and (5) Register August 2007 No. 620, eff. 9−1−07, except (5) (c) 2. eff. 1−1−08; CR 08−043: r. and recr. Register March 2009 No. 639, eff. 4−1−09; correction in (2) (c) 3., (3) (a) 2., (b) 2., (5) (a) 2., (d) 2., (6) (c), (9) (a) 3., 4., (c), (10) (d) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; **CR 14−015: am. (5) (b) 2. d. Register August 2014 No. 704, eff. 9−1−14.**

**SPS 320.10 Inspections. (1)** INSPECTOR CERTIFICATION. All inspections, for the purpose of administering and enforcing this code, shall be performed by an inspector certified in accordance with ch. SPS 305 who holds the respective credential for the inspection performed.

**(2)** GENERAL INSPECTION REQUIREMENTS. (a) *General.* Inspections shall be conducted by the municipality or authorized UDC inspection agency administering and enforcing this code to determine if the construction or installations conform to the conditionally approved plans, the Wisconsin uniform building permit application and the provisions of this code.

(b) *Inspection notice.* 1. The applicant or an authorized representative shall request inspections from the municipality or authorized UDC inspection agency administering and enforcing this code.

2. Except as provided under subd. 3., construction may not proceed beyond the point of inspection until the inspection has been completed.

3. Construction may proceed if the inspection has not taken place by the end of the second business day following the day of notification or as otherwise agreed between the applicant and the municipality or authorized UDC inspection agency.

**(3)** INSPECTION TYPES. (a) *General.* The inspections described in pars. (b) to (i) shall be performed to determine if the work complies with this code.

(b) *Erosion control inspection.* Erosion control inspections shall be performed concurrently with all other required construction inspections. Additional inspections for erosion control may be performed by the delegated authority.

(c) *Foundation excavation inspection.* 1. The excavation for the foundation shall be inspected after the placement of any forms or required reinforcement and prior to the placement of the permanent foundation material.

2. If a drain tile system is required, by the local inspector or by groundwater levels in the excavation, the presence and location of bleeders used to connect the interior and exterior drain tile shall be inspected at the same time as the excavation.

**Note:** This excavation inspection may be used to determine the need for drain tile under s. SPS 321.17.

(d) *Foundation reinforcement inspection.* The placement of reinforcement shall be inspected where the reinforcement is required for code compliance.

(e) *Foundation inspection.* The foundation shall be inspected after completion. Where dampproofing, exterior insulation or drain tile are required for code compliance, the foundation shall be inspected prior to backfilling.

(f) *Rough inspection.* 1. A rough inspection shall be performed for each inspection category listed under subd. 1. a. to e. after the rough work is constructed but before it is concealed.

a. The basement floor area.

**Note:** The inspection of the basement floor area should include the following: any underfloor plumbing, electrical, or HVAC; any interior drain tile with base course required under s. SPS 321.17; the structural base course for the floor slab if required under s. SPS 321.20; and the underfloor vapor retarder as required under s. SPS 322.38.

b. General construction, including framing.

c. Rough electrical.

d. Rough plumbing.

e. Rough heating, ventilating and air conditioning.

2. All categories of work for rough inspections may be completed before the notice for inspection is given, provided the work has not been covered.

3. The applicant may request one rough inspection or individual rough inspections.

4. A separate fee may be charged for each individual inspection.

(g) *Insulation inspection.* An inspection shall be made of the insulation and vapor retarders after they are installed but before they are concealed.

(h) *Final inspection.* 1. Except as provided under subd. 2., the dwelling may not be occupied until a final inspection has been made that finds no critical violations of this code that could reasonably be expected to affect the health or safety of a person using the dwelling.

2. Occupancy may proceed in accordance with local ordinances if the inspection has not been completed by the end of the fifth business day following the day of notification or as otherwise agreed between the applicant and the department or municipality.

(i) *Installation inspection.* An inspection shall be performed on the installation of a manufactured home or modular home.

**Note:** The design and construction of manufactured homes is regulated by the federal Department of Housing and Urban Development under Title 24 CFR Part 3280.

**(4)** NOTICE OF COMPLIANCE OR NONCOMPLIANCE. (a) *General.* 1. Notice of compliance or noncompliance with this code shall be written on the building permit or another readily visible means and posted at the job site.

2. Upon finding of noncompliance, the municipality or authorized UDC inspection agency enforcing this code shall also notify the applicant of record and the owner, in writing, of the violations to be corrected.

3. Except as specified under par. (b), the municipality or authorized UDC inspection agency shall order all cited violations corrected within 30 days after written notification, unless an extension of time is granted under s. SPS 320.21.

(b) *Erosion and sediment control requirements.* 1. The time period allowed for compliance with the erosion and sediment control provisions under s. SPS 321.125 shall be determined based on the severity of the noncompliance in relation to soil loss or potential damage to the waters of the state.

2. Pursuant to s. 101.653 (7) (b), Stats., the department, a municipality or the designated UDC inspection agency may issue a special order directing an immediate cessation of construction work on other aspects of the dwelling until compliance with the erosion and sediment control provisions under s. SPS 321.125 is attained. Construction work may resume once the erosion and sediment control compliance corrections are completed.

**Note:** Section 101.653 (7) (b) reads: "The department or a city, village, town or county may issue a special order directing the immediate cessation of work on a one−or 2−family dwelling until the necessary plan approval is obtained or until the site complies with the rules promulgated under sub. (2)."

**(5)** VOLUNTARY INSPECTION. The department or its authorized representative may, at the request of the owner or the lawful occupant, enter and inspect dwellings, subject to the provisions of this code, to ascertain compliance with this code.

**(6)** RECORD KEEPING. (a) *Municipal enforcement.* Municipalities that have adopted an ordinance to enforce this code shall maintain records in accordance with all of the following:

1. A record shall be made of each visit to a site, each inspection type performed and the pass or fail results of each inspection.

2. Approved plans shall be retained for 4 years after completion of the dwelling.

3. Applications forms, correction orders, correspondence and inspection records shall be maintained for 7 years after completion of the dwelling.

(b) *State enforcement.* Inspectors working under state contract shall maintain records in accordance with the provisions of the contract that was in effect at the time the inspections were completed.

**Note:** Records generated by the plan review and inspection functions are public records and are subject to the open−records law.

**History:** Cr. Register, November, 1979, No. 287, eff. 6−1−80; am. (1) (a), Register, February, 1985, No. 350, eff. 3−1−85; cr. (1) (b) 2. f., Register, January, 1989, No. 397, eff. 2−1−89; correction (1) (b) 2. intro. made under s. 13.93 (2m) (b) 4., Stats., Register, January, 1989, No. 397; r. (1) (b) 2. e., renum. (1) (b) 2. f. and 3. and (3) to be (1) (b) 2. e. and 4. and (2), cr. (1) (b) 3., Register, March, 1992, No. 435, eff. 4−1−92; am. (1) (c), Register, September, 1992, No. 441, eff. 12−1−92; cr. (1) (b) 5., Register, November, 1995, No. 479, eff. 12−1−95; am. (intro.), Register, October, 1996, No. 490, eff. 11−1−96; r. and recr. (1) (c), Register, February, 1997, No. 494, eff. 3−1−97; am. (intro.), Register, March, 1998, No. 507, eff. 4−1−98; r. and recr. (1) (b) 4., Register, March, 2001, No. 543, eff. 4−1−01; CR 00−159: am. (1) (intro.), (c) 1. and 2. a., r. and recr. (1) (a), Register September 2001 No. 549 eff. 12−1−01; CR 05−113: r. and recr. (1) (c) 2. Register December 2006 No. 612, eff. 4−1−07; CR 06−071: am. (1) (b) (intro.) cr. (1) (b) 6. and (3) Register December 2006 No. 612, eff. 4−1−07; CR 08−043: r. and recr. Register March 2009 No. 639, eff. 4−1−09; correction in (3) (i) made under s. 13.92 (4) (b) 7., Stats., Register March 2009 No. 639; correction in (1), (4) (a) 3., (b) 1., 2. made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

**SPS 320.11 Suspension or revocation of Wisconsin uniform building permit. (1)** (a) The municipality or the registered UDC inspection agency administering and enforcing this code may suspend or revoke any Wisconsin uniform building permit where it appears that the permit or approval was obtained through fraud or deceit, where the applicant has willfully refused to correct a violation order or where the inspector is denied access to the premises.

(b) No construction may take place on the dwelling after suspension or revocation of the permit.

**(2)** Any person aggrieved by a determination made by the department, a municipality or a registered UDC inspection agency may appeal the decision in accordance with s. SPS 320.21.

**History:** Cr. Register, November, 1979, No. 287, eff. 6−1−80; CR 00−159: r. (1), renum. (intro.) to be (1), am. (2), Register, September 2001 No. 549 eff. 12−1−01; correction in (2) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

## Subchapter V — Approval and Inspection of Modular Homes and Their Components

**SPS 320.12 Scope.** This part shall govern the design, manufacture, installation and inspection of modular homes, manufactured building systems and the components of the building systems displaying the Wisconsin insignia.

**History:** Cr. Register, November, 1979, No. 287, eff. 6−1−80; correction made under s. 13.92 (4) (b) 7., Stats., Register March 2009 No. 639.

**SPS 320.13 Manufacture, sale and installation of homes. (1)** MANUFACTURE AND SALE. No modular home, manufactured building system or component of the building system subject to this part shall be manufactured for use, sold for initial use or installed in this state unless it is approved by the department and it bears the Wisconsin insignia issued or a state seal or an insignia reciprocally recognized by the department.

**(2)** INSTALLATION. A Wisconsin uniform building permit shall be obtained in accordance with s. SPS 320.09 (1) to (5) (a) before any on−site construction falling within the scope of this code is commenced for a modular home. The permit shall be issued in accordance with s. SPS 320.09 (9).

**History:** Cr. Register, November, 1979, No. 287, eff. 6−1−80; correction in (2) made under s. 13.93 (2m) (b) 7., Stats., Register August 2007 No. 620; CR 08−043: am. (2) Register March 2009 No. 639, eff. 4−1−09; correction in (1) made under s. 13.92 (4) (b) 7., Stats., Register March 2009 No. 639; correction in (2) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

**SPS 320.14 Approval procedures. (1)** APPLICATION FOR APPROVAL. (a) An application for approval of any modular home, building system or component shall be submitted to the department in the form required by the department, along with the appropriate fees in accordance with s. SPS 302.34.

(b) The department shall review and make a determination on an application for approval of a modular home, building system or component within 3 months.

**(2)** APPROVAL OF BUILDING SYSTEMS AND COMPONENTS. (a) *Approval of building systems.* 1. 'Plans and specifications.' All plans and specifications shall be submitted to the department according to subd. 1. a. or b.:

a. Three complete sets of building, structural, mechanical and electrical plans, (including elevations, sections and details), specifications and calculations shall be submitted to the department on behalf of the manufacturer for examination and approval.

b. At least one complete set of building, structural, mechanical and electrical plans, (including elevations, sections and details), specifications and calculations shall be submitted to the department on behalf of a manufacturer. All plans and specifications submitted to the department shall be stamped "conditionally approved" by a UDC certified inspector or inspectors.

2. 'Compliance assurance program.' a. Three sets of the compliance assurance program shall be submitted for examination and approval.

b. The compliance assurance program shall meet the standards of the Model Documents for the Evaluation, Approval and Inspection of Manufactured Buildings or an equivalent standard acceptable to the department.

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# Conditioned Crawl Space Construction, Performance and Codes

Building America Report - 0401

2004-11-02 by Joseph Lstiburek, Building Science Corporation

Abstract:

*Conditioned crawl spaces perform better than vented crawl spaces in terms of safety, health, comfort, durability and energy consumption. Conditioned crawl spaces also do not cost more to construct than vented crawl spaces. Existing vented crawl spaces are experiencing serious moisture and mold problems and are costing builders and homeowners significant resources to repair. Despite the obvious problems with existing vented crawl spaces and the obvious benefits of conditioned crawl spaces there is not a significant trend towards the construction of conditioned crawlspaces. One of the reasons typically cited by builders and designers is "the code does not allow me to build unvented crawl spaces". This is both generally correct and misleading. The model codes do not allow the construction of "unvented" crawl spaces – except in very limited circumstances, but they do allow the construction of "conditioned" crawl spaces. The distinction is important and necessary. Four conditioned crawl spaces were constructed and monitored over a 12-month period. The data is presented and used to support the current code requirements for the construction of conditioned crawl spaces.*

# BUILDING AMERICA

# SYSTEMS ENGINEERING APPROACH TO DEVELOPMENT OF ADVANCED RESIDENTIAL BUILDINGS

## 5.C.2.4 CONDITIONED CRAWL SPACE CONSTRUCTION, PERFORMANCE AND CODES

RE: TASK ORDER NO. KAAX-3-32443-4, 5, AND 6
UNDER
TASK ORDERING AGREEMENT NO. KAR-8-18412-00

MIDWEST RESEARCH INSTITUTE,
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APRIL-AIRE, INC.
CARRIER
GREENFIBER
DOW CHEMICAL COMPANY
MASCO
CERTAINTEED
FORTIFIBER

NOVEMBER 2, 2004

# Conditioned Crawlspace Construction, Performance and Codes

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**Abstract**

Conditioned crawl spaces perform better than vented crawl spaces in terms of safety, health, comfort, durability and energy consumption. Conditioned crawl spaces also do not cost more to construct than vented crawl spaces. Existing vented crawl spaces are experiencing serious moisture and mold problems and are costing builder's and homeowners significant resources to repair. Despite the obvious problems with existing vented crawl spaces and the obvious benefits of conditioned crawl spaces there is not a significant trend towards the construction of conditioned crawlspaces. One of the reasons typically cited by builders and designers is "the code does not allow me to build unvented crawl spaces". This is both generally correct and misleading. The model codes do not allow the construction of "unvented" crawl spaces – except in very limited circumstances, but they do allow the construction of "conditioned" crawl spaces. The distinction is important and necessary. Four conditioned crawl spaces were constructed and monitored over a 12 month period. The data is presented and used to support the current code requirements for the construction of conditioned crawl spaces.

**Background**

Crawl space venting is generally viewed as good practice despite the obvious moisture problems that occur when outside air with a dew point higher than interior crawl space surface temperature is permitted to enter a crawl space. Unvented, conditioned crawl spaces with insulation on the perimeter solve this problem. Unvented, conditioned crawl spaces with insulation on the perimeter perform better in terms of safety and health (pest control), comfort (warm floors, uniform temperatures), durability (moisture) and energy consumption than passively vented crawl spaces with sub floor insulation.

Perimeter insulation rather than floor insulation performs better in all climates from an energy conservation perspective. The crawl space temperatures, dew points and relative humidities track that of the house. Crawl spaces insulated on the perimeter are warmer and drier than crawl spaces insulated between the crawl space and the house. Cold surfaces that can condense water are minimized when crawl spaces are conditioned.

Wintertime ventilation makes crawl spaces colder and increases the heat loss from the home – venting crawl spaces wastes energy, and can lead to freezing pipes and uncomfortable floors.

Crawl spaces should be designed and constructed as mini-basements, part of the house – within the conditioned space. They should be insulated on their perimeters and should have a continuous sealed ground cover such as taped polyethylene. They should have perimeter drainage just like a basement when the crawl space ground level is below the ground level of the surrounding grade.

**Constructing Conditioned Crawl Spaces**

Crawl spaces should be designed and constructed to be dry. A dry crawl space is less likely to have pests and termites and mold. A dry crawl space is therefore safer and healthier than a wet crawl space. Crawl spaces must control rainwater, groundwater and provide drainage for potential plumbing leaks or flooding incidents (Figure 1).

Crawl spaces must always have a drying mechanism. One of the most effective ways to provide a drying mechanism to a crawl space is to condition a crawl space by heating and cooling the crawl space as if the crawl space is included as part of the home. Air must be supplied to the crawl space from the home in order to provide this conditioning. This air can be returned back to the home or it can be exhausted (Figure 2, Figure 3, Figure 4 and Figure 5). Crawl spaces can also be included as part of the home (conditioning them) by connecting them to conditioned basements (Figure 6 and Figure 7).

Crawl spaces must always have a ground cover that prevents evaporation of ground moisture into the crawl space. There are many ways to provide a durable ground cover or liner. The option used depends on the resources available, the frequency of people entering the crawl space to either store possessions or to maintain equipment. One of the

most effective is 6 mil sheet polyethylene that has taped/sealed joints and that is attached to the crawl space perimeter walls. This ground cover must be continuous through piers and supports (Figure 8).

Crawl space perimeter walls should also be insulated. The perimeter walls can be insulated either internally or externally (Figure 9, Figure 10 and Figure 11). When insulating crawl spaces internally (as well as basements) it is important to not leave concrete or masonry exposed in order to control condensation – this is particularly important at perimeter foundation wall "steps" or changes in height (Figure 12). It is similarly necessary to control condensation at rim joist areas. This is best done using rigid insulation installed either externally to the rim joist or internally against the rim joist.

Air permeable insulation such as fiberglass batts, fiberglass blankets or spray applied cellulose should be avoided when insulating crawl space perimeters and rim joist assemblies. The air permeance characteristics of these types of insulations do not prevent moisture laden air from accessing surfaces that may be cold enough to condense water.

Where radon gas is a concern, a soil gas ventilation system can be installed under the ground cover (Figure 13).

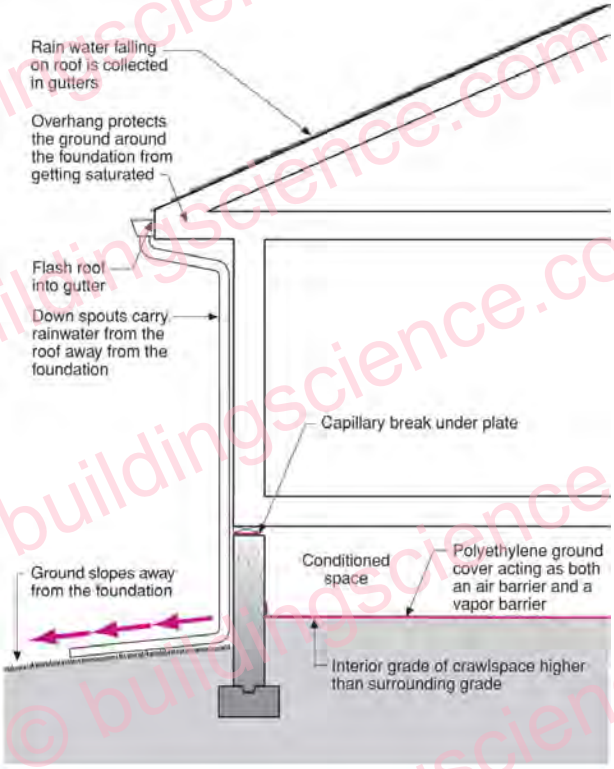


**Figure 1**
**Groundwater Control with Crawlspaces**

- Keep rain water away from the foundation perimeter
- If the interior crawlspace is lower than the exterior grade, a sub-grade perimeter footing drain is necessary as in a basement foundation
- The crawlspace in this configuration is conditioned space; it is part of the "interior" of the building and should be heated, cooled and ventilated as part of the building's heating, cooling and ventilating strategy

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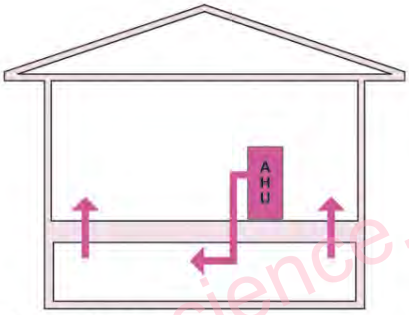
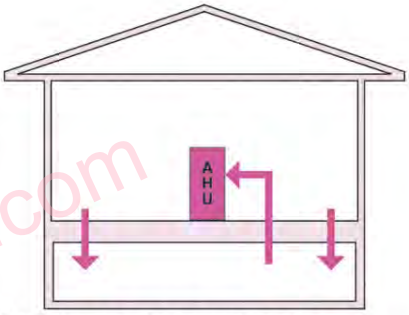


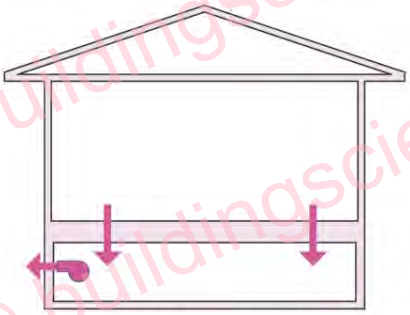

**A: Supply air to crawlspace**

- Minimum 2-4"x8" transfer grilles **to** house
- 20 cfm of flow per 1,000ft² of crawlspace
- Air handler cycled at 5 minutes per hour



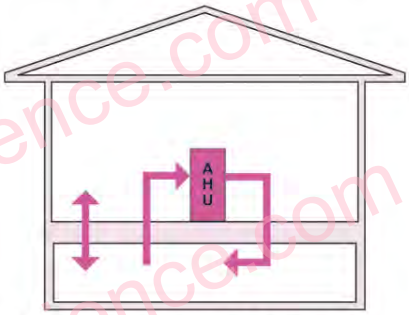

**C: Return air from crawlspace**

- Minimum 2-4"x8" transfer grilles **from** house
- 20 cfm of flow per 1,000ft² of crawlspace
- Air handler cycled at 5 minutes per hour



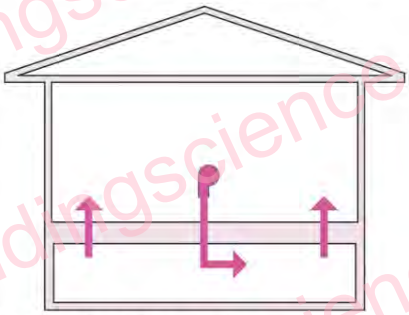
**B: Exhaust fan in crawlspace**

- Transfer air **from** house
- 20 cfm of flow per 1,000ft² of crawlspace
- Fan sized at ASHRAE 62.2 whole house flow rates:
  7.5 cfm/person + 0.01 cfm/ft² of conditioned area
- For a 2,000ft² 3 bedroom house with 4 occupants:
  4 x 7.5 cfm = 30 cfm
  2,000ft² x 0.01 cfm = 20 cfm
  30 cfm + 20 cfm = 50 cfm (i.e. 50 cfm exhaust fan)
- Fan runs continuously




**D: Supply and return to crawlspace**

- Minimum 2-4"x8" transfer grilles **from** house through floor to equalize air pressure
- 20 cfm of flow per 1,000ft² of crawlspace
- Air handler cycled at 5 minutes per hour



**E: Supply air to crawlspace**

- Minimum 2-4"x8" transfer grilles **to** house
- 20 cfm of flow per 1,000ft² of crawlspace

**Figure 2**
**Conditioning Crawlspaces**

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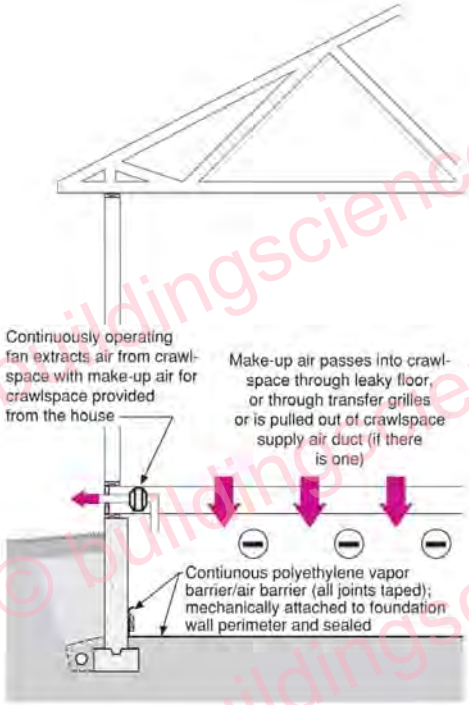


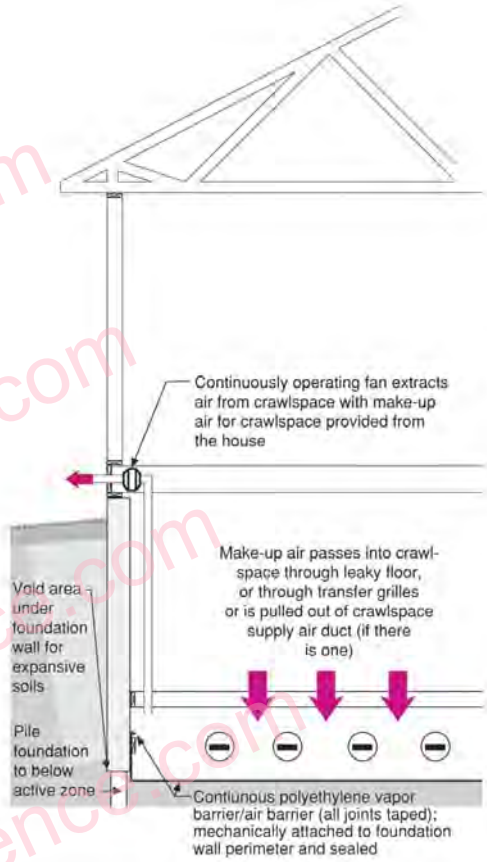


**Figure 3**
**Controlled Mechanical Ventilation, Soil Gas and Crawlspace Ventilation System**

- Crawlspace is conditioned (heated during the winter, cooled during the summer) either by make-up air pulled from the house or by a supply HVAC system duct
- Depressurization of crawlspace is facilitated by continuous exhaust from the crawlspace with make-up air for the crawlspace provided from the house common area
- Crawlspace ground cover is tighter than subfloor
- Crawlspace ventilation and house ventilation is provided by a single fan

**Figure 4**
**Combined Controlled Ventilation, Soil Gas and Crawlspace Ventilation System**

- Crawlspace is conditioned (heated during the winter, cooled during the summer) either by make-up air pulled from the house or by a supply HVAC system duct
- In regions with expansive soils and suspended wood basement floors over crawlspaces, depressurization of crawlspace can be facilitated by continuous exhaust from the crawlspace with make-up air for the crawlspace provided from the house common area
- Crawlspace ground cover is tighter than subfloor
- Crawlspace ventilation and house ventilation is provided by a single fan

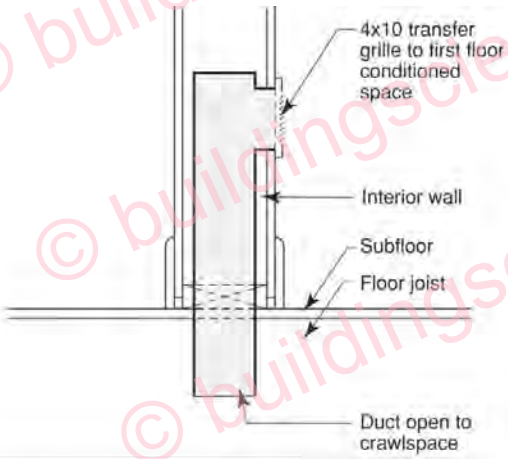


**Figure 5**
**Transfer Grille to Crawlspace**

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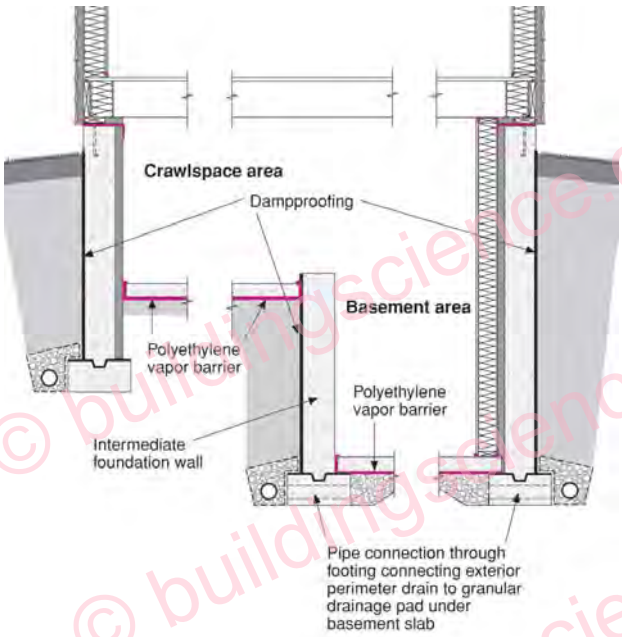


**Figure 6**
**Connecting Crawlspace and Basement**

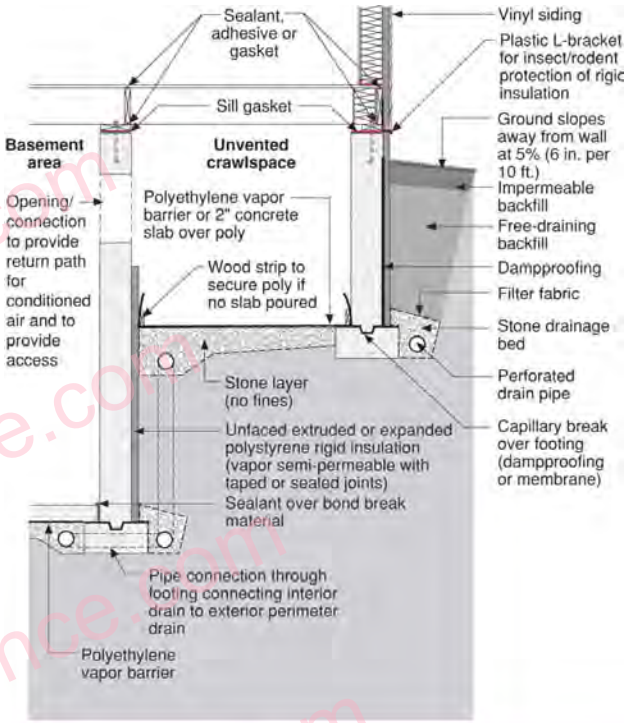


**Figure 7**
**Connecting Crawlspace and Basement**

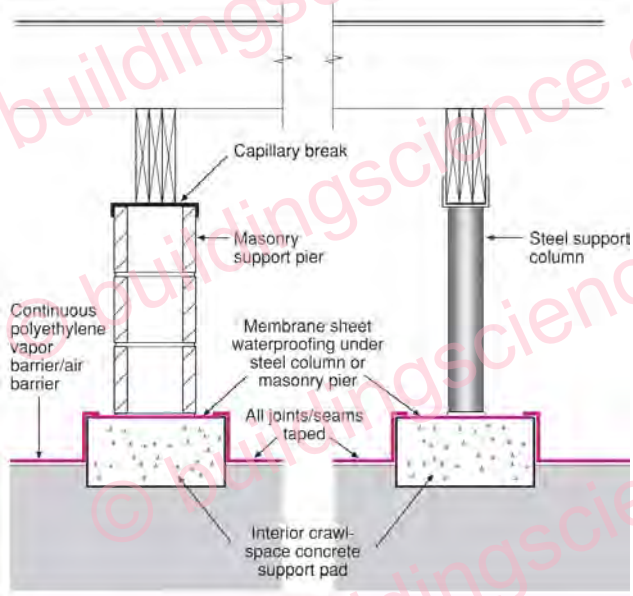


**Figure 8**
**Air Barrier Continuity at Piers**

- All joints and seams in polyethylene are taped
- Polyethylene ground cover taped to membrane sheet waterproofing at columns and piers

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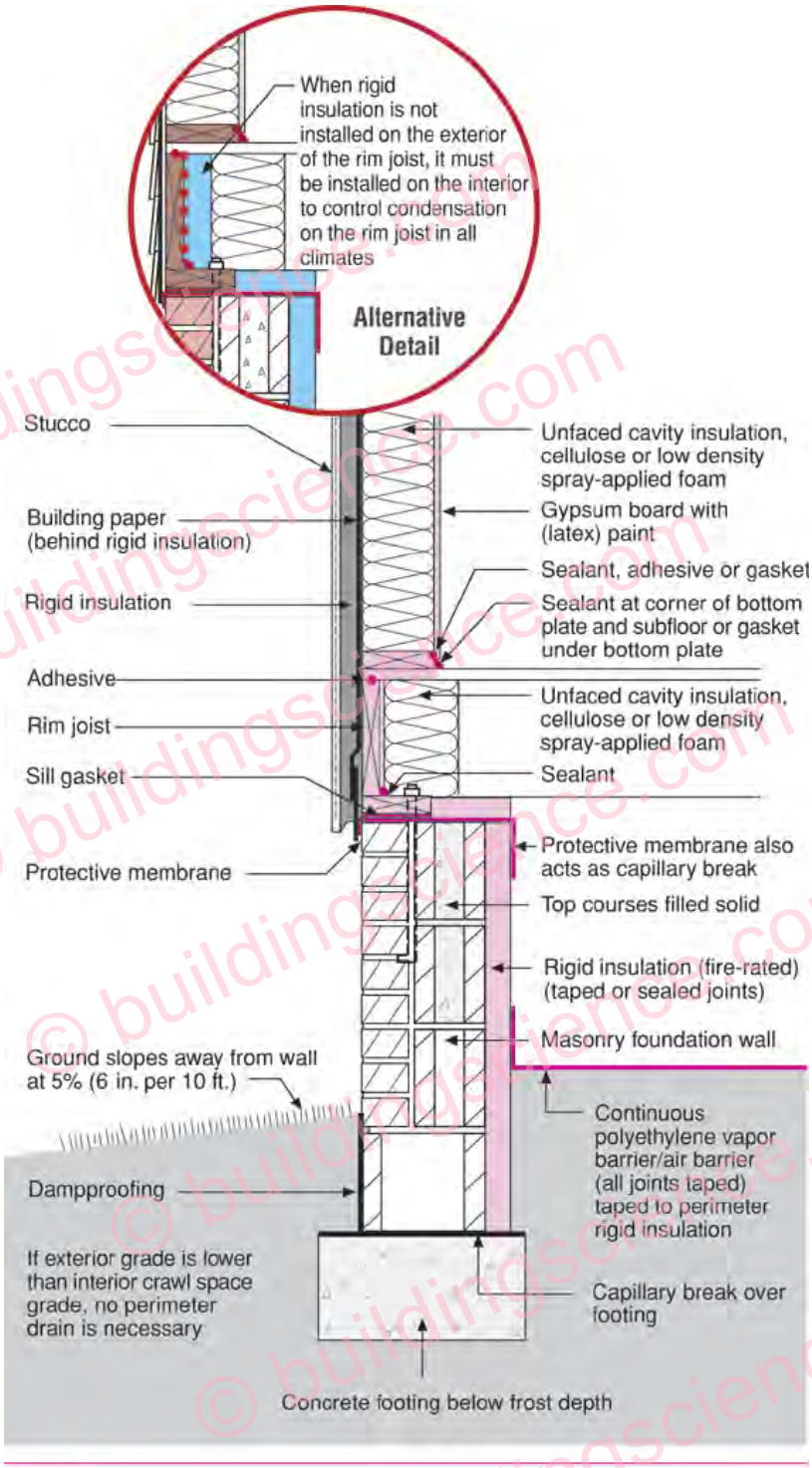


**Figure 9**
**Internally Insulated Concrete Crawlspace with Stucco Wall Above**

- Masonry wall can dry to exterior
- Protective membrane acts as termite barrier
- Rigid insulation must be fire-rated if it is left exposed on the interior
- Building paper installed shingle fashion acts as drainage plane located behind rigid insulation

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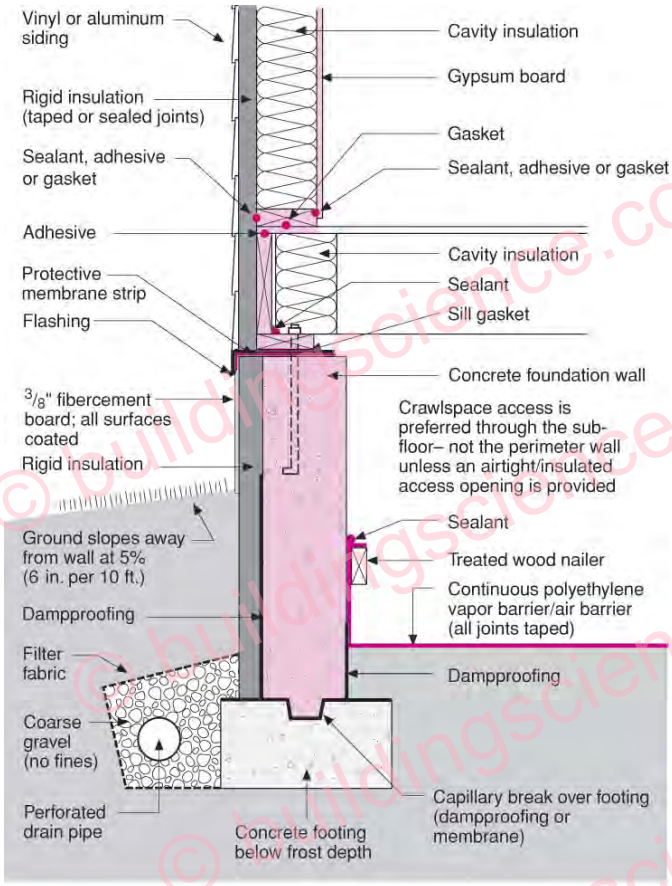


**Figure 10**
**Externally Insulated Concrete Crawlspace with Vinyl or Aluminum Siding Above**

- Concrete wall warm, can dry to the interior; extremely low likelihood of mold
- Protective membrane acts as termite barrier
- Perimeter drain is necessary since interior grade is lower than exterior grade
- Protective membrane can be adhesive-backed roll roofing, below grade sheet waterproofing or an ice-dam protection membrane

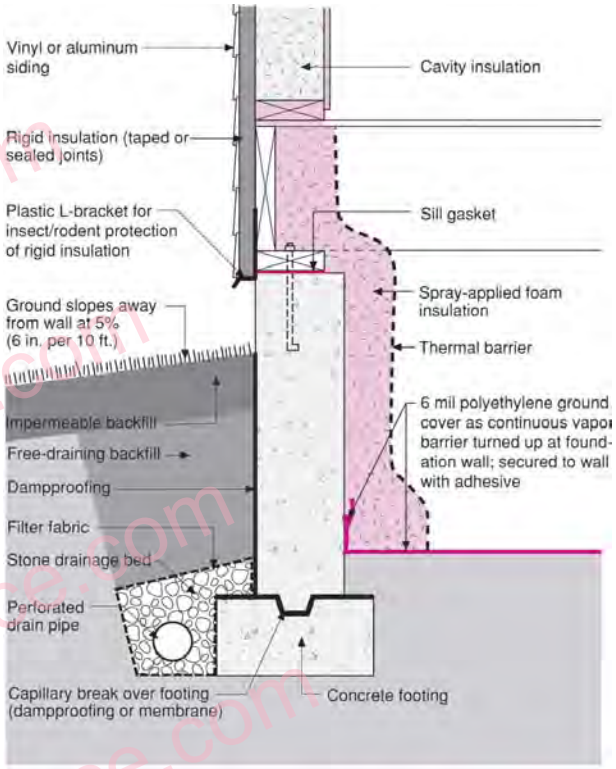


**Figure 11**
**Internally Insulated Concrete Crawlspace with Spray Foam**

- A thermal barrier must be installed over spray foam insulations in crawlspaces

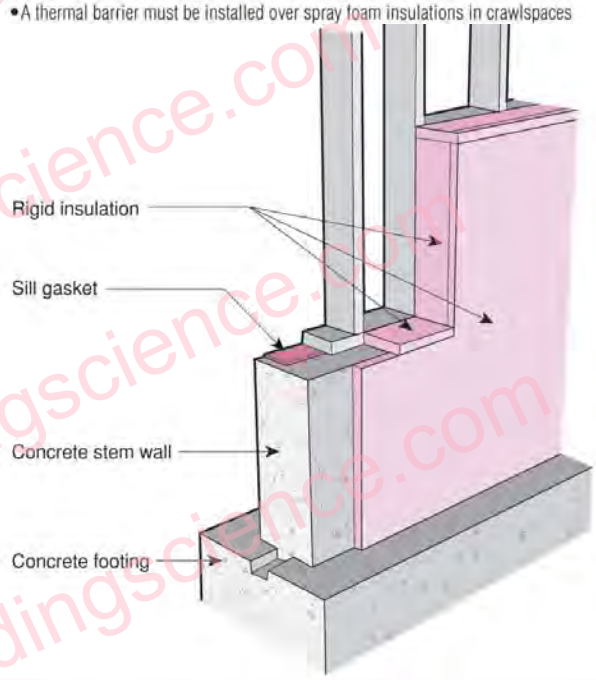


**Figure 12**
**Step Down Foundation Wall**

- In basement assemblies and conditioned crawlspace assemblies that are internally insulated, it is important that rigid insulation "wraps" around exposed concrete/block assemblies at "step downs" in order to control condensation, particularly during summer months

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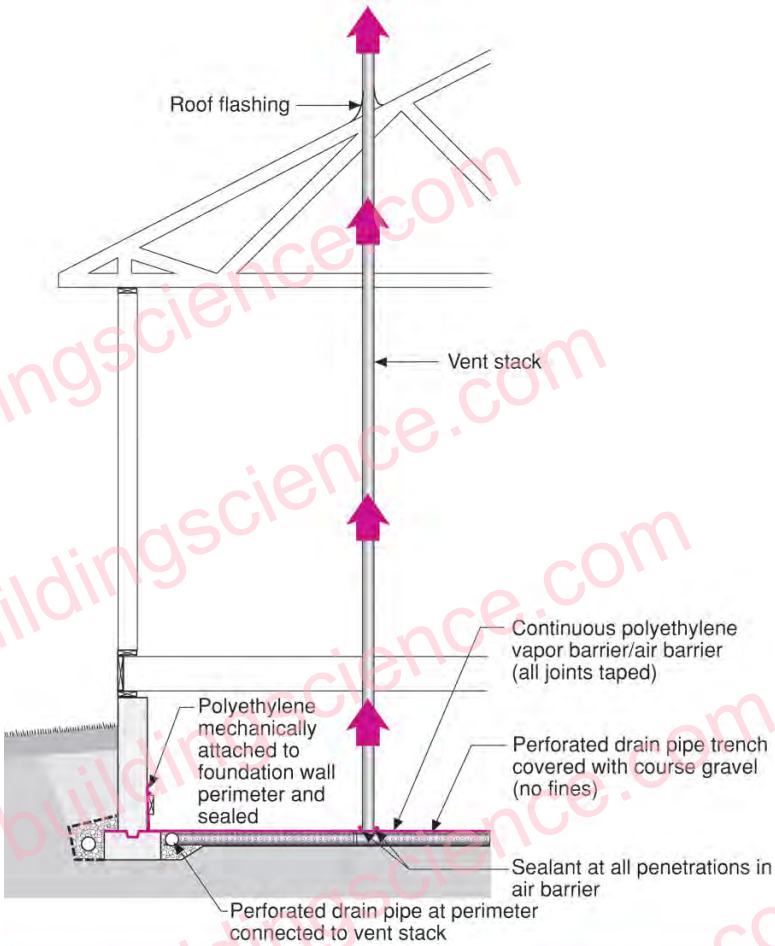


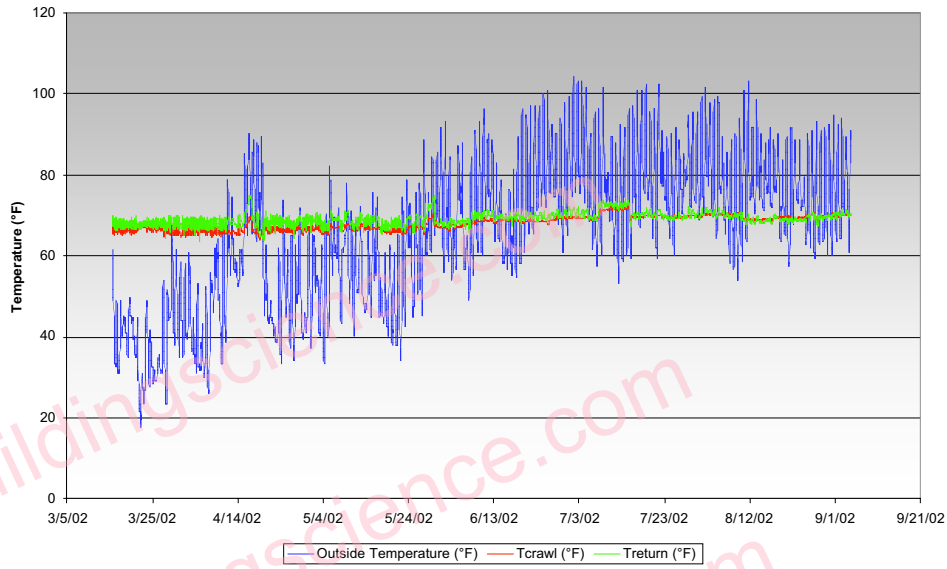

**Figure 13**
**Soil Gas Ventilation System — Crawlspace Construction**

- Perforated drain pipe in trenches covered with coarse gravel create depressurized zones under air barrier due to active fan located in attic or by passive stack action of warm vent stack located inside heated space
- Crawlspace is conditioned (heated during the winter, cooled during the summer) by a supply HVAC system duct
- Perforated drain pipe may not be necessary with tightly sealed polyethylene and coarse gravel
- Perimeter trench connected to centrally located vent stack

**Conditioned Crawl Space Performance**

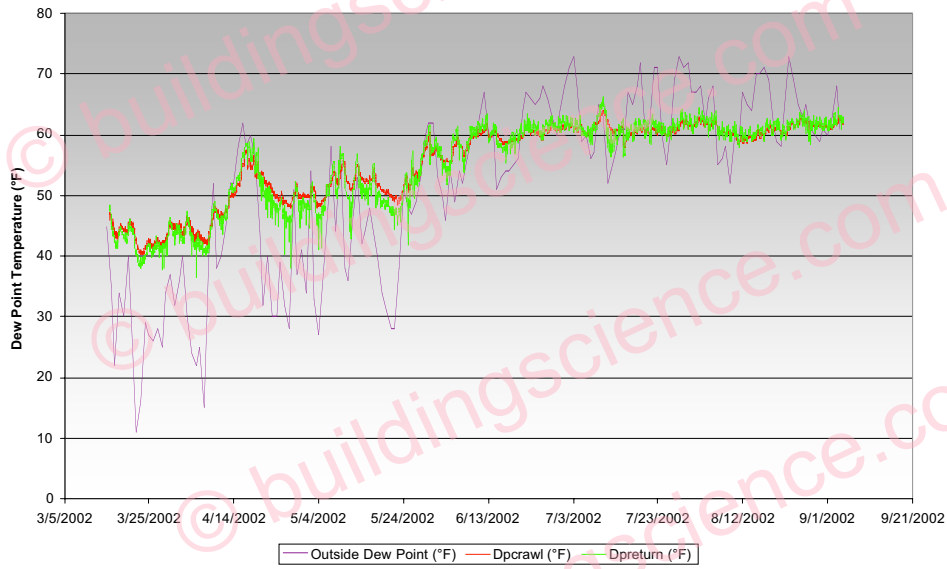
Three conditioned crawl spaces were constructed in Ohio (one in Cleveland, two in Columbus) and one conditioned crawl space was constructed in Albuquerque, New Mexico. The crawl spaces were monitored over a twelve-month period.

The Cleveland House plots of indoor, outdoor and crawl space temperature are presented in Graph 1. Note how closely the crawl space temperature tracks the indoor temperature. The Cleveland House has an active supply duct providing conditioned air to the crawl space. Transfer grilles provide a return path to the indoor space above the crawl space.




**Graph 1: Cleveland House Indoor, Outdoor, and Crawlspace Temperatures**

The Cleveland House plots of indoor, outdoor and crawl space dew point temperature are presented in Graph 2. Again note how closely the crawl space dew point tracks the indoor dew point.




**Graph 2: Cleveland House Indoor, Outdoor, and Crawlspace Dew Point Temperatures**

The Cleveland House plots of indoor relative humidity and crawl space relative humidity are presented in Graph 3. The crawl space relative humidity again closely tracks the indoor relative humidity.

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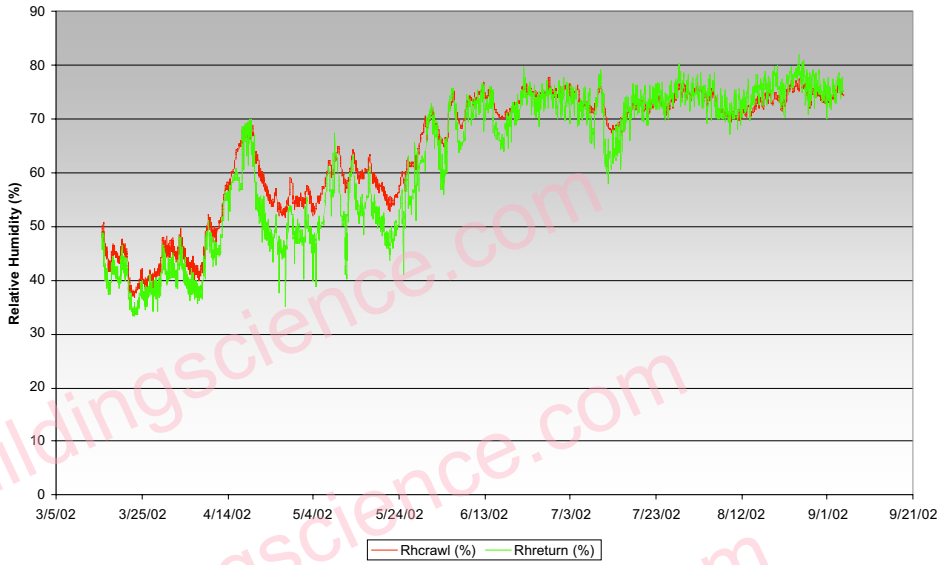
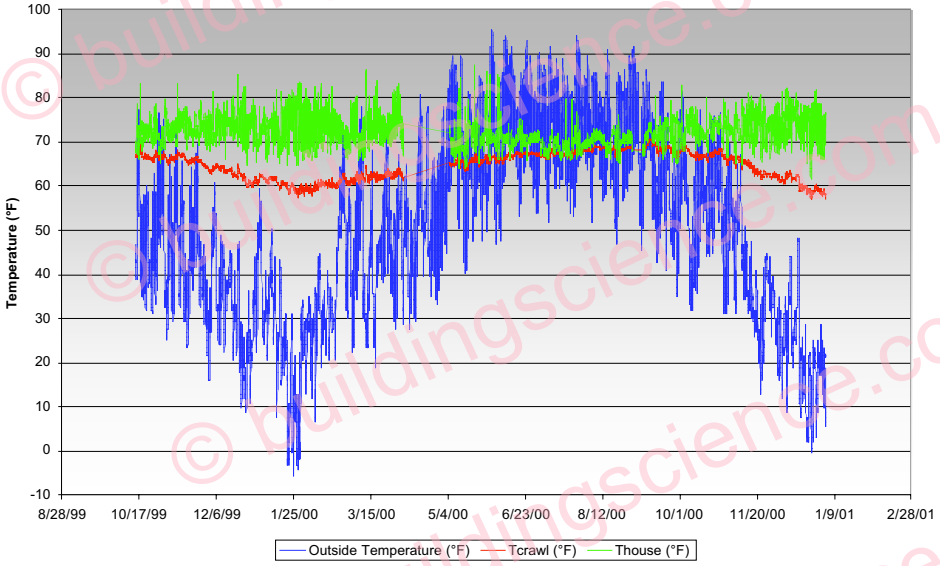



**Graph 3: Cleveland House Indoor and Crawlspace Relative Humidity**

The Gates House (Columbus) plots of indoor, outdoor and crawl space temperature are presented in Graph 4. In this home, the crawl space is somewhat cooler than the indoor temperature by 5 to 10 degrees. The Gates house crawl space is "passively" connected to the interior with transfer grilles only (no supply duct was provided to the crawl space).




**Graph 4: Gates House (Columbus) Indoor, Outdoor, and Crawlspace Temperatures**

The Gates House (Columbus) plots of indoor, outdoor and crawl space dew point temperature are presented in Graph 5. The crawl space dew point is consistently higher than the indoor dew point. Again, however, the crawl space dew point does track the indoor dew point.

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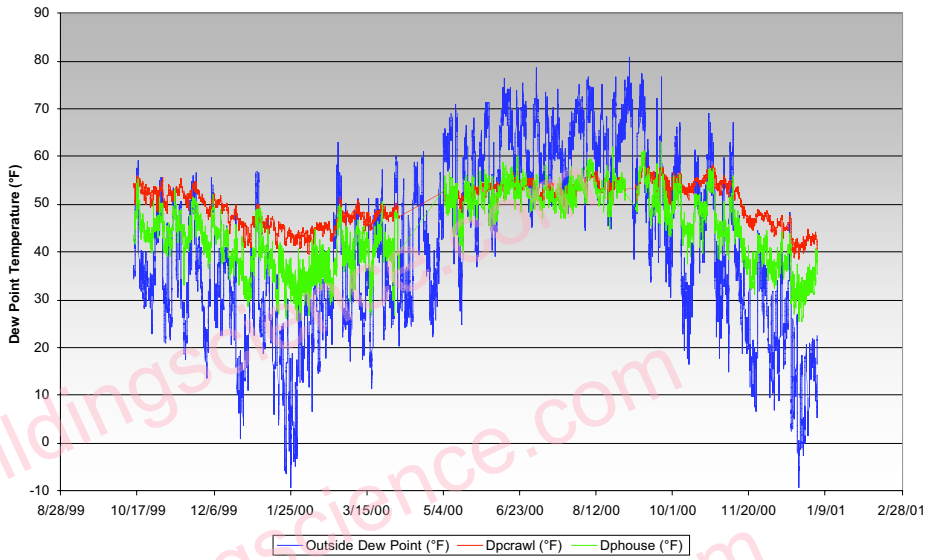
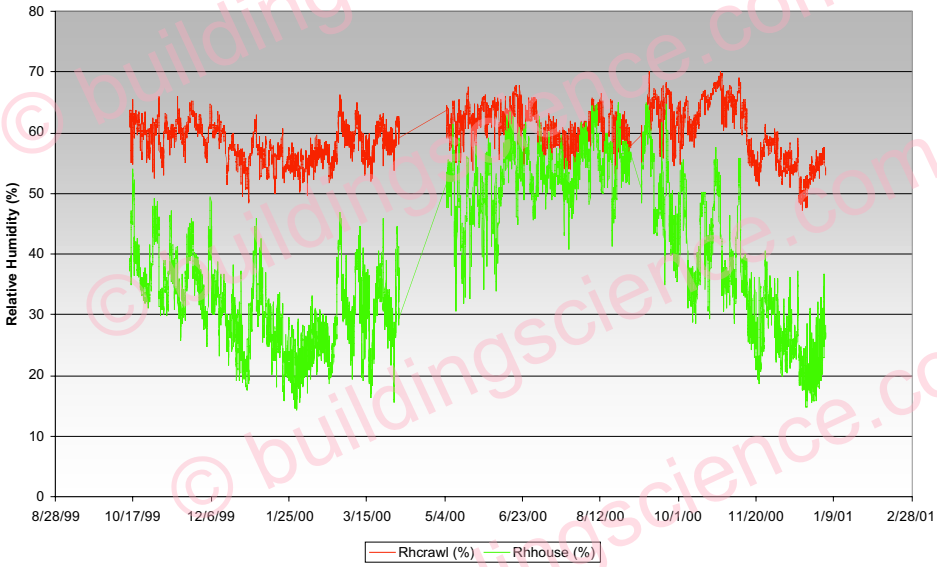



**Graph 5: Gates House (Columbus) Indoor, Outdoor, and Crawlspace Dew Point Temperatures**

The Gates House (Columbus) plots of indoor relative humidity and crawl space relative humidity are presented in Graph 6. The crawl space relative humidity is consistently higher than the house relative humidity – as would be expected from the previous temperature plots and dew point plots.




**Graph 6: Gates House (Columbus) Indoor and Crawlspace Relative Humidity**

The Meeder House (Columbus) plots of indoor, outdoor and crawl space temperature are presented in Graph 7. The crawl space temperature closely tracks the indoor temperature. Like the Cleveland House, the Meeder House has an active supply duct providing conditioned air to the crawl space and transfer grilles providing a return path to the indoor space above the crawl space.

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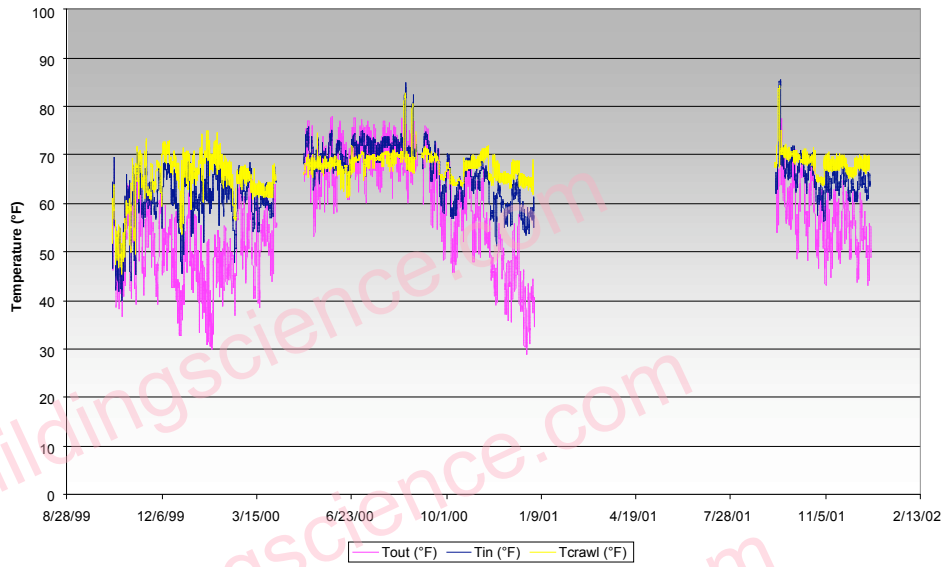
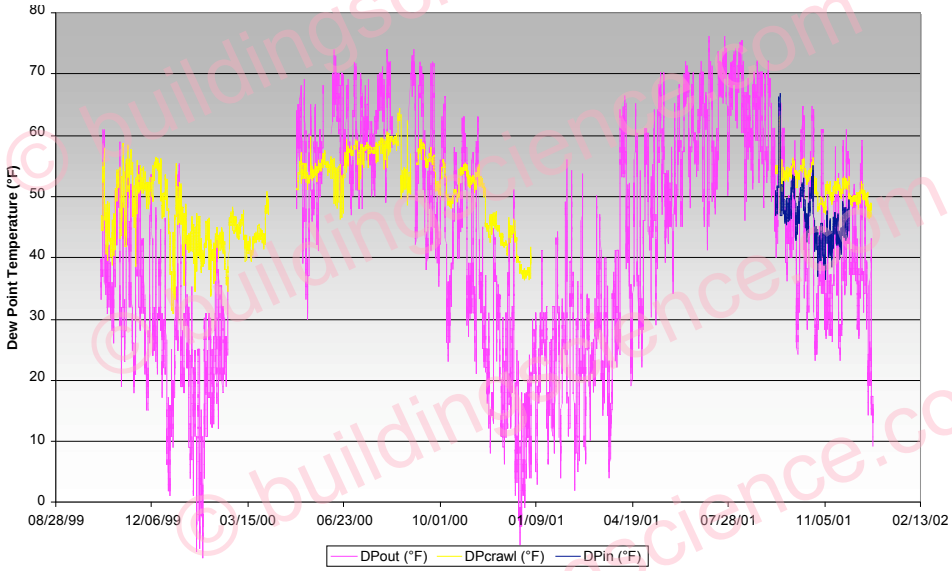



**Graph 7: Meeder House (Columbus) Indoor, Outdoor, and Crawlspace Temperatures**

The Meeder House (Columbus) plots of indoor, outdoor and crawl space dew point temperature are presented in Graph 8. Again note how closely the crawl space dew point tracks the indoor dew point.




**Graph 8: Meeder House (Columbus) Indoor, Outdoor, and Crawlspace Dew Point Temperatures**

The Meeder House (Columbus) plots of indoor relative humidity and crawl space relative humidity are presented in Graph 9. The crawl space relative humidity again tracks the indoor relative humidity.

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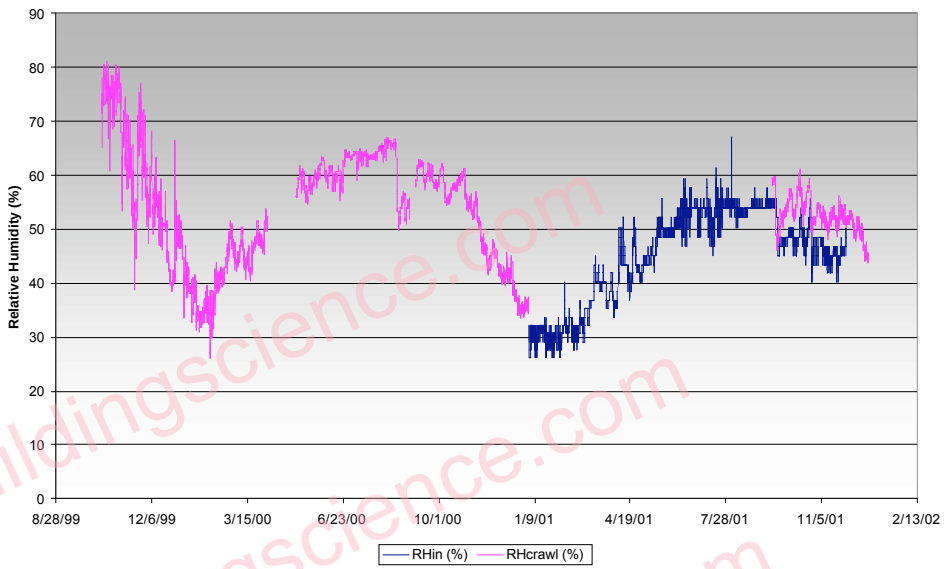
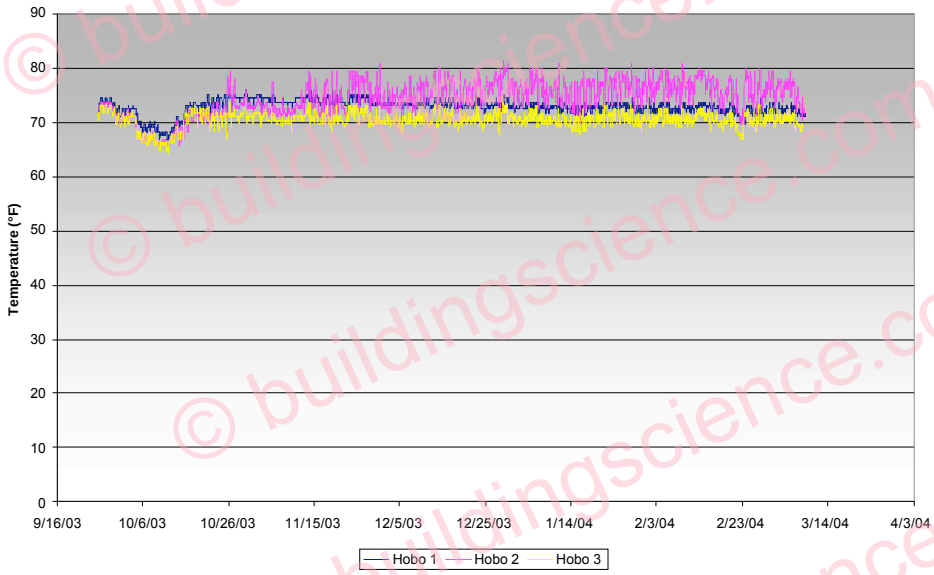



**Graph 9: Meeder House (Columbus) Indoor and Crawl Space Relative Humidity**

The Albuquerque House plot of crawl space temperature is presented in Graph 10, the Albuquerque House plot of crawl space dew point temperature is presented in Graph 11 and the Albuquerque House plot of crawl space relative humidity is presented in Graph 12. Note how steady, consistent and "flat" the plots are for temperature, dew point and relative humidity. The Albuquerque House crawl space contains an active supply duct providing conditioned air to the crawl space. Transfer grilles provide a return path to the indoor space above the crawl space.




**Graph 10: Albuquerque House Crawlspace Temperature**

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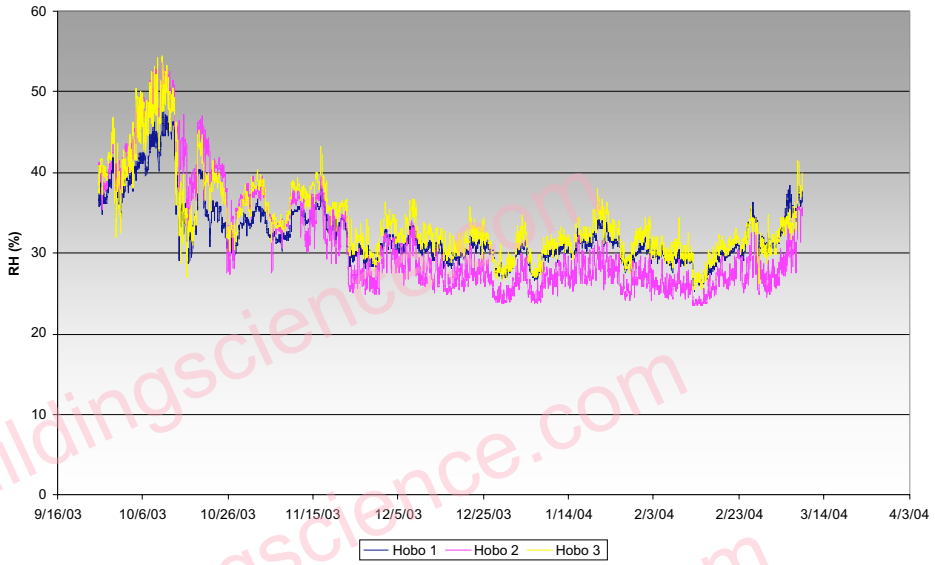


**Graph 12: Albuquerque House Crawlspace Relative Humidity**

The differences between the crawl spaces that are "actively" conditioned (the Cleveland House, the Meeder House and the Albuquerque House) versus the crawl space that is "passively" conditioned (Gates House) are quite significant. Active conditioning, as can be expected, does a much better job of controlling conditions in the crawl space. As will be noted later, in the Code discussion, the model codes require "active conditioning". Based on the monitored data, this appears to be a good idea. As can be expected, there will always be situations where "active" conditioning is unnecessary – such as dry climates and where small crawl spaces are well connected to conditioned basement spaces.

**Code Language**

The 2003 International Mechanical Code (IMC), the 2003 International Building Code (IBC), the 2004 Supplement to the International Energy Conservation Code (IECC) and the 2004 Supplement to the International Residential Code (IRC) are all very explicit regarding crawl spaces, ventilation, ground covers, insulation and conditioning.

Singularly and in combination the model codes require that unventilated crawl spaces (i.e. those without passive crawl space vents connecting the crawl space to the exterior) be constructed with continuous ground covers, have their perimeter walls insulated and the crawl space to be conditioned:

***2003 International Mechanical Code***
*Chapter 4 Ventilation*
*Section 406 Ventilation of Uninhabited Spaces*

*406.1 General. Uninhabited spaces, such as crawl spaces and attics, shall be provided with natural ventilation openings as required by the International Building Code or shall be provided with a mechanical exhaust and supply air system. The mechanical exhaust rate shall be not less than 0.02 cfm per square foot (0.00001 m3/s – m2) or horizontal area and shall be automatically controlled to operate when the relative humidity in the space served exceeds 60 percent.*

The 2003 IMC tells you that unvented crawls spaces must be provided with a mechanical exhaust and supply air system and sets the rate and the conditions of operation (i.e. a relative humidity limit is set).

***2003 International Building Code***
*Chapter 12 Interior Environment*

*1203.3 Under-Floor Ventilation.*

*1203.3.1 Openings For Under-Floor Ventilation.*

*1203.3.2. Exceptions. The following are exceptions to Sections 1203.3 and 1203.3.1:*

1. *Where warranted by climatic conditions, ventilation openings to the outdoors are not required if ventilation openings to the interior are provided.*

2. *Ventilation openings are not required where continuously operated mechanical ventilation is provided at a rate of 1.0 cubic foot per minute (cfm) for each 50 square feet (1.02 L/s for each 10 m2) of crawl space floor area and the ground surface is covered with an approved vapor retarder.*

3. *Ventilation openings are not required when the ground surface is covered with an approved vapor retarder, the perimeter walls are insulated and the space is conditioned in accordance with the International Energy Conservation Code.*

***2004 Supplement to the IECC***
*IECC, Section 402, Building Thermal Envelope*

*402.2.8 Crawl Space Walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous vapor retarder. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.*

***2004 Supplement To The IRC***
*IRC, Section R408.3, Unvented Crawl Space*

*R408.3 Unvented Crawl Space. Ventilation openings in under-floor spaces specified in Sections R408.1 and R408.2 shall not be required where:*

1. *Exposed earth is covered with a continuous vapor retarder. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall,*

2. *And one of the following is provided for the under-floor space:*

    a. *Continuously operated mechanical exhaust ventilation at a rate equal to 1 cfm (0.47 L/s) for each 50 ft2 (4.7 m2) 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 N1102.2.8, or*

    b. *Conditioned air supply sized to deliver at a rate equal to 1 cfm (0.47 L/s) for each 50 ft2 (4.7 m2) 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 N1102.2.8, or*

    c. *Plenum complying with Section M1601.4, if under-floor space is used as a plenum.*

The 2003 IBC tells you that ventilation openings are not always required based on the climate if ventilation openings to the interior are provided. It goes on to say that ventilation openings are also not required if mechanical ventilation is provided and it tells you how much to provide. Finally, the 2003 IBC says that ventilation openings are not required if a ground cover is provided and the crawl space perimeter is insulated and the crawl space is conditioned in accordance with the IECC.

The 2004 Supplement to the IECC tells you that you do not have to insulate the floor of a crawl space if you insulate the perimeter of the crawl space, it tells you how much insulation to install and it tells you that a ground cover is required. The 2004 Supplement to the IECC also provides the following definition for a conditioned space:

*Conditioned Space. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent conditioned space.*

The 2004 Supplement to the IRC tells you that ventilation openings are not necessary if you have a ground cover and if you provide some form of conditioning. It explicitly allows three approaches to conditioning. The first uses the concept of transfer air where air from the living space (which is a conditioned space) is pulled into the crawl space via a duct or transfer grille due to the exhaust action of a fan that pulls air out of the crawl space and exhausts it to the exterior. The size of the fan is also specified. The second uses the concept of supply air and a return air pathway – an approach similar to that of providing conditioning to a bedroom or a basement. The quantity of conditioning air is also specified. The third uses the concept of the crawl space as a supply plenum. In this plenum approach to conditioning additional specific requirements are required and are referenced in Section M1601.4:

***2003 International Residential Code***
*Chapter 16 Duct Systems*

*M1601.4 Under Floor Plenums. An under-floor space used as a supply plenum shall conform to the requirements of this section. Fuel gas lines and plumbing waste cleanouts shall not be located within the space.*

*M1601.4.1 General. The space shall be cleaned of loose combustible materials and scrap, and shall be tightly enclosed. The ground surface of the space shall be covered with a moisture barrier having a minimum thickness of 4 mils (0.102 mm).*

*M1601.4.2 Materials. The under-floor space, including the sidewall insulation, shall be formed by materials having flame-spread ratings not greater than 200 when tested in accordance with ASTM E 84.*

*M1601.4.3 Furnace Connections. A duct shall extend from the furnace supply outlet to not less than 6 inches (152 mm) below the combustible framing. This duct shall comply with the provisions of Section M1601.1. A noncombustible receptacle shall be installed below any floor opening into the plenum in accordance with the following requirements:*

1. *The receptacle shall be securely suspended from the floor members and shall not be more than 18 inches (457 mm) below the floor opening.*
2. *The area of the receptacle shall extend 3 inches (76 mm) beyond the opening on all sides.*
3. *The perimeter of the receptacle shall have a vertical lip of at least 1 inch (25.4 mm) high at the open sides.*

*M1601.4.4 Access. Access to an under-floor plenum shall be provided through an opening in the floor with minimum dimensions of 18 inches by 24 inches (457 mm by 610 mm).*

*M1601.4.5 Furnace Controls. The furnace shall be equipped with an automatic control that will start the air-circulating fan when the air in the furnace bonnet reaches a temperature not greater than 150 degrees F (66 degrees C). The furnace shall additionally be equipped with an approved automatic control that limits the outlet air temperature to 200 degrees F (93 degrees C).*

This section is also quite specific. It only applies when the crawl space is used as a plenum. In other words when using R408.3, 2, (c) not when using R408.3.2, (a) or R408.3.2 (b). Many builders and many building code officials erroneously interpret the code to require that the provisions of Section M1601.4 apply to all conditioned crawl spaces and not just to crawl spaces that are used as supply plenums.

A plenum is defined in the 2003 IRC as:

*Plenum. A chamber that forms part of an air-circulation system other than the occupied space being conditioned.*

A conditioned crawl space is by definition the space that is being conditioned when air is supplied to it via a supply duct or via a transfer grille or opening. It is therefore not a plenum. A crawl space is only a plenum when the crawl space is supplying air to the space above (or adjacent to it) for the purpose of conditioning the space above (or adjacent to it).

The issue is some what muddied when it is argued that the requirements do not apply to crawl spaces if it is interpreted that a crawl space is not an “occupied space”. If the crawl space is considered a utility space or storage

space or simply a conditioned space and these types of spaces are also considered "occupied space" then the issue is moot. The 2003 IRC is not helpful as it defines occupied space as follows:

*Occupied Space. The total area of all buildings or structures on any lot or parcel of ground projected on a horizontal plane, excluding permitted projections as allowed by this code.*

This definition was clearly not intended to apply to this particular issue although if this language is strictly and literally interpreted the matter once again becomes moot as under this definition a crawl space is "occupied space" regardless of whether it is vented or not, conditioned or not.

The 2003 International Mechanical Code (IMC) defines a plenum as follows:

*Plenum. An enclosed portion of the building structure, other than an occupiable space being conditioned, that is designed to allow air movement, an thereby serve as part of an air distribution system.*

This is somewhat different than the definition in the 2003 IRC. The term occupiable space is used rather than occupied space. The 2003 IMC does not define occupiable space. For the definition of occupiable space we have to go to the 2003 IBC:

*Occupiable Space. A room or an enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with a means of egress and light and ventilation facilities meeting the requirements of this code.*

Under this definition, a conditioned crawl space clearly does not meet the definition of occupiable space. Also, equally clearly, the issue of conditioned crawl spaces was not considered when this particular definition was established. Although you could argue that sometimes people go into crawl spaces for amusement or education purposes – and we do typically provide light in a conditioned crawl space (a light bulb and switch) and ventilation via provisions for supplying and returning or exhausting air and therefore a conditioned crawl space is an occupiable space. Of course, this type or augment is ridiculous in the extreme and is as weak as to the augment used by some individuals to include conditioned crawl spaces in the definition of plenums since the existing plenum definitions contain references to occupied space or occupiable space.

The 2004 Supplement to the IRC clearly intended to treat conditioned crawl spaces differently than crawl spaces that are designed to be used as plenums since a separate requirement/provision was provided for crawl spaces used as plenums in the code language. The definitions section of the code needs to be cleared up to make this explicitly clear. Until this happens there will continue to be individuals using the occupiable space definition as a club to require the provisions of Section M1601.4 to apply to all conditioned crawl spaces.

An extremely simple way to clear up the confusion is to alter the definition of a plenum by deleting the word "occupied" from the existing definition in the 2003 IRC. The new definition would read as follows:

*Plenum. A chamber that forms part of an air-circulation system other than the space being conditioned.*

In the 2003 IMC the definition of plenum should also be altered by deleting the words "an occupiable" and replacing them with the word "the" so that the new definition would read as follows:

*Plenum. An enclosed portion of the building structure, other than the space being conditioned, that is designed to allow air movement, an thereby serve as part of an air distribution system.*

Alternatively, a definition of "occupiable space" could be provided for the 2003 IRC and the word "occupied" in the definition of "plenum" be changed to "occupiable". The definintion of "occupiable space" for the 2003 IRC could read as follows:

*Occupiable Space: Any room or enclosed space intended for human activities, including but not limited to, all bedrooms, kitchens, dining rooms, bathrooms, toilets, closets, halls, storage and utility areas, laundry areas and conditioned crawl spaces and conditioned attic spaces.*

The bottom line is that crawl space ventilation is not required by the model codes if:

- a ground cover is provided
- the perimeter walls are insulated
- the crawl space is conditioned

Based on the field testing and experience, these are good requirements. However, the issue of plenum definition still needs to be clarified so that the explicit language of the model codes meets the obvious intent of the model codes regarding conditioned crawl spaces.

## About this Report

This report was prepared for the US Department of Energy's Building America Program (see Building America cover page for more information). The report is freely available to the public at www.buildingamerica.gov.

## About the Author

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# CLOSED CRAWL SPACES:

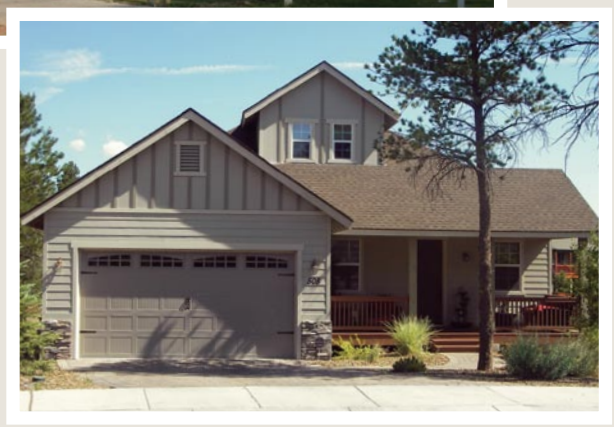
## TOP PERFORMERS NATIONWIDE

### *New research shows that properly closed crawl spaces earn their keep*

FROM ADVANCED ENERGY'S APPLIED BUILDING SCIENCE TEAM
DECEMBER 2009

Research results indicate that closed crawl spaces are a great moisture control strategy and also save energy if the installer follows climate-appropriate insulation strategies, as reported by Advanced Energy, a Raleigh, N.C.-based nonprofit.

It's no secret that wall-vented crawl spaces can breed mold and moisture — leading to rot, structural failure and unhealthy indoor air. In 2005, Advanced Energy showed that properly closed crawl spaces in central



BATON ROUGE HOME, TOP.
FLAGSTAFF BELOW.

North Carolina minimize these problems and provide energy savings, but it was questioned whether they would perform equally well in other climate zones.

Advanced Energy recently completed similar studies in two new locations, the results of which show that closed crawl spaces deliver performance improvements in varying climates.

## The Homes

Researchers monitored two sets of new homes in different climates: a 15-home modular housing development in hot, humid Baton Rouge, La.; and 12 stick-framed homes in cold, dry Flagstaff, Ariz.

To keep moisture out of the crawl space, installers sealed gaps and penetrations in the crawl space walls, then covered the walls with a 6 mil reinforced clear polyethylene vapor retarder. An 8 mil white version was applied over the earth floor and sealed to the wall liner.

In Baton Rouge, researchers tested three closed crawl space designs with two heating, ventilation and air conditioning (HVAC) ductwork configurations:

- Three homes with R-8 Thermax foam board on the foundation walls, and ductwork in the crawl space (**CCS-W-C**).
- Four homes with R-8 Thermax foam board on the foundation walls and ductwork in the attic (**CCS-W-A**).
- Four homes with R-19 fiberglass batts between the floor joists and ductwork in the attic (**CCS-F-A**).

***Researchers monitored two sets of new homes in different climates: a 15-home modular housing development in hot, humid Baton Rouge, La.; and 12 stick-framed homes in cold, dry Flagstaff, Ariz.***

Every Baton Rouge home with a closed crawl space had a small supply duct that delivered conditioned air to the crawl space whenever the HVAC system was running.

In Flagstaff, researchers tested two closed crawl space designs, both with ductwork in the crawl space.

- Four homes with R-30 fiberglass batts between the floor joists (**CCS-F-C**).
- Four homes with R-13 Thermax foam board on the foundation walls (**CCS-W-C**).

SUPPLY AIR DUCT IN A CRAWL SPACE

Each site included four control homes (**CTL**) built with locally code-compliant vented crawls. The ductwork in Baton Rouge control homes was in the attic, and the ductwork in Flagstaff control homes was in the crawl space.

## The Results

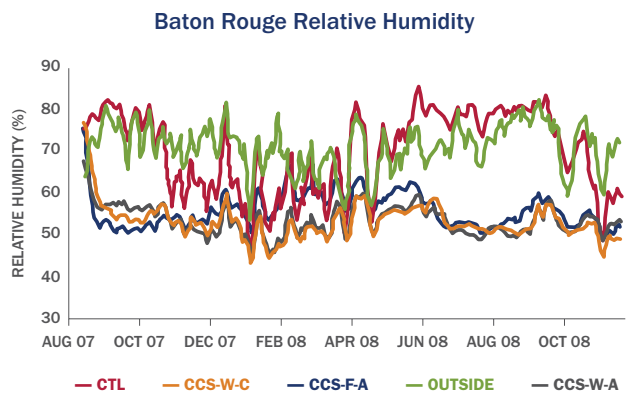
Researchers measured crawl space humidity and home energy use for more than a year in Baton Rouge and for five months in Flagstaff. While the closed crawl spaces stayed considerably drier than the controls, energy use was more varied and included some surprises.

### MOISTURE CONTROL

The primary reason for closing a crawl space is to keep it dry. As intended, humidity stayed low in all the closed crawl spaces regardless of climate, insulation or duct placement.

In Baton Rouge, average daily relative humidity (RH) in closed crawls barely exceeded 60 percent, even in summer, while the vented control crawl spaces often exceeded 80 percent. In Flagstaff, crawl spaces in the control homes remained less than 70 percent RH, but the crawls with the sealed liner system performed even better, never exceeding 50 percent RH.

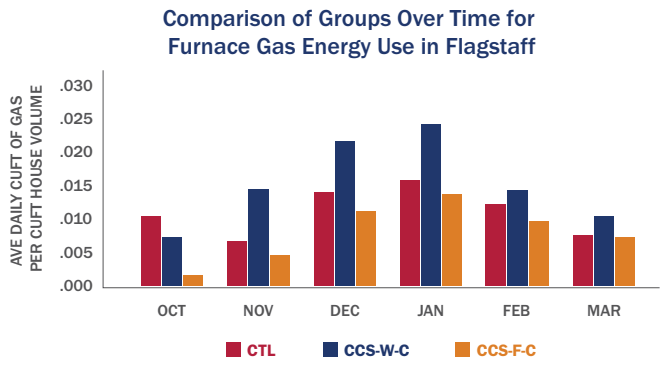
The research clearly indicates that properly closed crawl spaces are a robust tool for humidity control.




### ENERGY SAVINGS

While moisture reduction was consistent, energy savings varied with climate, insulation and duct placement.

In Flagstaff, researchers monitored energy use throughout a single heating season. While the homes with insulated floors used 20 percent less natural gas than the controls, those with insulated foundation walls used 53 percent more.




This seemed counterintuitive; ducts are a notorious source of heat loss. With all the Flagstaff homes' ductwork in the crawl space, one would expect better performance from the warmer, wall-insulated crawl spaces. But according to Cyrus Dastur, the Advanced Energy building scientist who directed the research, those homes' lack of floor insulation let heat radiate from the first floor to the crawl space, robbing more heat from the house than was saved by keeping the ductwork warm.

The research makes it evident that in cold climates, it's better to insulate the floor above the closed crawl space than to insulate the foundation walls.

Baton Rouge results also varied, ranging from a 6 percent savings to a 29 percent penalty. Here, homeowner behavior and the location of insulation and ductwork appears to have caused significant variation. While Advanced Energy plans more monitoring to quantify the impact of occupants in the home, duct placement had an unmistakable effect. Among homes with attic ducts, those with wall-insulated

*The research makes it evident that in cold climates, it's better to insulate the floor above the closed crawl space than to insulate the foundation walls.*

crawl spaces performed better in some months while those with floor-insulated crawls did better in other months. But homes with ducts in wall-insulated closed crawls used less energy all year.

*The research indicates that in a hot climate, energy performance is optimized by locating HVAC ductwork in a wall-insulated closed crawl space.*

The research indicates that in a hot climate, energy performance is optimized by locating HVAC ductwork in a wall-insulated closed crawl space.

### RADON WORRIES

Radon can be a concern with closed crawl spaces (in this regard, a closed crawl space is like a short basement), and indeed the Flagstaff closed crawl spaces were re-vented after the discovery of elevated radon levels. Dastur echoes the recommendation of the Environmental Protection Agency (EPA) to test for radon in all homes. Where there is a known radon risk, builders should follow EPA's radon-ready guidelines. If testing indicates elevated radon after the crawl space is complete, the mitigation system can be activated with the addition of an appropriate exhaust fan.

## Ensuring Performance

Performance of the closed crawl space over time was also in question. For instance, could a plumbing leak puddle on the floor and raise humidity? Dastur says that while several homes had such leaks, RH did not noticeably increase.

Maintenance of the air seal is a bigger concern. A Baton Rouge homeowner installed a satellite dish after moving in. Despite a large sign inside the crawl space indicating that it must remain sealed, the satellite dish installer left a large hole in the wall liner. A wireless remote humidity sensor indicated the problem and repairs were made before any damage occurred. Advanced Energy recommends the installation of wireless humidity sensors in closed crawl spaces, paired with an alarm inside the home, to catch such problems.

The biggest challenge to getting a properly closed crawl space is finding a qualified installer. Crawl spaces in this study were installed to Advanced Energy's guidelines by professionals from E3 Energy and CrawlSpace Care Technologies (CSCT). Advanced Energy is developing a training curriculum that it plans to offer through electric utilities and builder groups, and CSCT provides both training and materials distribution.

*The biggest challenge to getting a properly closed crawl space is finding a qualified installer.*

Dastur reports that the cost for a closed crawl space in a new N.C. home is typically less than $2 per square foot. While the air quality and durability benefits alone can make this a worthwhile investment, an added benefit is that the energy savings may pay for the system well before the owners pay off the mortgage.

Advanced ENERGY

**For more information about closed crawl spaces, visit**
**www.crawlspaces.org or call (919) 857-9000.**

## Finishing the Crawl Space

**An unfinished crawl space can present moisture issues, harbor mold and decrease a home's energy efficiency. A finished crawl space can result in a greener, healthier home.**

The crawl space is not an area where many homeowners dare to venture. It is often dark, damp and cold—uninviting, to say the least. If left "unfinished," this seldom-visited underbelly of the home can reduce the indoor air quality of the living areas above, cause moisture-related problems to the structure of the home and increase utility costs. A qualified basement or crawl space contractor will be the homeowner's best bet for finishing the home's crawl space.

Crawl Space Blues

Crawls spaces may appear to serve little purpose, but in truth they have a few important functions. To start, a crawl space may have been used in place of a basement to save cost. The crawl space elevates the home off the ground (as opposed to a slab), which can be a necessity in particularly damp or termite-prone locations. The crawl space can also house the plumbing and ductwork of a home and grants access to repair or service those systems. They may not be transformable into a game room or den, but clearly the crawl space adds some benefit to the home.

BEFORE. An encapsulation system seals the walls and the dirt floor of the crawl space. Photo courtesy of the Crawlspace Doctor.

AFTER. An encapsulation system seals the walls and the dirt floor of the crawl space. Photo courtesy of the Crawlspace Doctor.

Unfortunately, an unfinished crawl space can also be quietly undermining the integrity of the home and life within it. The crawl space—like many unfinished basements—tends to be quite humid. The excessive moisture in a crawl space poses a number of threats to the home. It provides an environment for mold to thrive—mold that can eventually make its way up into the rest of the home. The moisture can also attract wood-boring insects that destroy the wood sub-structure. The presence of insects may also draw rodents and other pests into the crawl space. Solving the crawl space moisture issue is the first priority in a crawl space finishing project.

The unfinished crawl space might also be increasing energy costs. Many crawl spaces have built-in ventilation to allow airflow—a code-enforced design originally intended to mitigate moisture. The latest studies on crawl space ventilation indicate that, in some climates, ventilation is actually contributing to moisture and humidity in the crawl space. Furthermore, ventilation allows winter cold to have free passage under the home, which can result in higher heating bills. Fortunately, there are some simple ways to "finish" the crawl space to reduce the moisture issues and increase energy efficiency.

Moisture Mitigation: Vapor Barriers and Encapsulation

The elimination of moisture and reduction of humidity in the crawl space is crucial to a healthy home. This step will help control mold growth, wood rot and insect infestation, which can also alleviate any rodent issues. Reducing moisture can put an end to any mustiness or unsavory smells emanating from the area. It will also prevent the hardwood floors above from warping.

Moisture and humidity in the crawl space is partially the result of water evaporating from the soil. To combat moisture in the crawl space, a vapor barrier or encapsulation system can be installed. "Encapsulating the whole crawl space is the best bet," says Mike Hogemson, owner of Standard Water Control, a basement and crawl space waterproofing company based in Crystal, Minn. "Vapor barrier," "moisture barrier" and "encapsulation" are all terms used by basement and crawl space professionals; it's important to know exactly what a contractor is using and how when it comes to eliminating moisture in the crawl space.

An encapsulation system usually sees a moisture/vapor barrier or "liner" installed up the walls of the crawl space and over the exposed earth floor. Proper installation methods of an encapsulation system will vary from climate to climate and are dependent on the specific products used, but it often includes overlapping the liners of the wall and the floor, taping all the seams and fixing the barrier to the foundation walls with anchors. The nature of the vapor barrier itself will vary by installer—some use products from outside manufacturers and some have their own patented and branded system. Vapor barriers differ in composition, thickness, strength or durability and color. Thickness can range anywhere between three to 20 millimeters; both puncture strength and tensile strength are rated—these are measured in pound-force (lbf). The type of barrier used should be taken into consideration by the homeowner and can be determined by the desired end result. "The homeowner needs to think about how the space will be used," says Hogemson. "Will the space be used for storage, or is [the encapsulation] just to protect your home?" An encapsulated crawl space that will be used for storage may require a thicker and more durable vapor barrier. A white product will also give the space a clean, finished look.

BEFORE. Removing the fallen insulation and installing a vapor barrier liner on the walls and the floor help give this crawl space a clean, finished look. Photo courtesy of the Crawlspace Doctor.

One of the most important features of the vapor barrier is the water vapor permeance—or "perm"—rating of the product. This measures the transmission of water vapor through the product. The lower the number, the better the product's resistance to vapor transmission. "Anything with a perm rating below .01 is considered a vapor barrier," says Dario Lamberti, product manager for the Moisture Control Division of Insulation Solutions. Based out of East Peoria, Ill., Insulation Solutions' line of products includes the Viper CS, a vapor barrier specifically designed for crawl space application. With a perm rating of .0095, the 6.5 ml. Viper CS outperforms many vapor barriers of 10 ml. thickness or more. "Our product has a cross-woven, reinforced design, which makes it very strong and durable," says Lamberti. Homeowners should ask the professional contractor which products would be used in a crawl space finishing project. Although a product like the Viper CS may be more expensive than many of its competitors, a homeowner may desire the peace of mind in knowing that the product is going to last and perform as intended.

AFTER. Removing the fallen insulation and installing a vapor barrier liner on the walls and the floor help give this crawl space a clean, finished look. Photo courtesy of the Crawlspace Doctor.

Just installing a vapor barrier most likely won't be enough, however. Professionals may recommend installing a drainage system along the perimeter of the crawl space walls and a sump pump to keep the ground beneath the liner dry. Leveling the dirt floor will be an option or a necessity, depending on whether or not the homeowner wants to pour a concrete floor, a more expensive crawl space finishing solution. A level crawl space is more conducive to storage usage and will decrease the chances of tearing a hole through the liner.

Some crawls spaces need a lot of work. Fiberglass insulation may need to be removed and replaced. Broken or leaking pipes, drier vents and other elements found in the crawl space may also be a source of moisture and humidity. A quality professional crawl space contractor will make sure the end result is a clean, dry and healthy room in the home.

Crawl Space Ventilation and Energy Efficiency

For some time, vents were code-enforced features on crawl spaces around the country. Recent findings have suggested that year-round venting of the crawl space is not beneficial for homes in every climate. In some cases, it can actually have a negative effect on both humidity levels in the crawl space and energy costs in the home.

Current thinking holds that the difference in air temperature outside the home to the temperature in the crawl space during the hot summer months causes moisture condensation inside the crawl space. This condensation forms on pipes, joists and just about every surface in the crawl space area, leading to mold growth and wood rot, which invites termites.

In the cold winter months, the vented crawl space permits cold outside air into the home. This cools down the pipes and heating elements in the crawl space (furnaces, ductwork, etc.), which can increase utility costs. It also can turn the floor above into an uncomfortably frigid surface to walk on.

"You wouldn't leave all the windows open year-round in a basement, yet this is what was being done in crawl spaces," says Tom Saucier, founder of the Crawlspace Doctor, Inc., a crawl space contracting company originally located in Springville, Ind. with franchises in seven states. While most new construction now has the option of vented or unvented crawl spaces, existing homes with vented crawl spaces would do well to cover up those vents. "You want to treat the crawl space just like any other room in the home," says Saucier.

This process starts by blocking up the vents. Sealing the crawl space from outside air is as important a step for moisture mitigation as installing a vapor barrier. This method will vary depending on the actual vents that are in place. This step may require removal of the vents and installing a new concrete block in its place. In some cases Styrofoam blocks and spray may be used on the interior of the crawl space—the vents stay in place but are rendered useless by the Styrofoam. A professional contractor with crawl space vent experience should be able to determine the best method for a given scenario.

It is important for a homeowner to check local code before blocking off crawl space vents. In some areas vents are required. Flood states, for example, require flood vents in this area of the home to prevent water pressure from destroying the foundation in the event of a flood. Crawl spaces that house a furnace or hot water heater may need make-up air for combustion purposes.

"Conditioning" the Crawl Space

To treat the crawl space like any other room in the home means "conditioning" it. In a crawl space that contains the ductwork for the home's heating system, conditioning the space is as simple as installing a register. This simple step will help keep the crawl space at the same temperature and humidity level as the rest of the rooms in the home. "The air becomes conditioned by using the existing HVAC system," says Saucier.

Of course, not all homes will have the option of installing a register in the crawl space area. For many homes, it may be necessary to use a dehumidifier in the crawl space area. Dehumidifiers vary widely—from small portable units on casters to crawl space-specific models that can be plumbed in to the home's drainage system. Similarly, the cost of a humidifier can range anywhere from a few hundred dollars to over $1,000. Units can be installed permanently and hard-piped to the home's existing drainage or the crawl space drainage. Dehumidifiers will be sized to treat a maximum square footage and have a minimum and maximum operating temperature. They are also rated by the number of pints of water per day the unit can remove from the humid air and the number of pints per kilowatt-hour (pints/kWh). A local HVAC professional or crawl space contractor can help the homeowner determine if a dehumidifier is the best option.

Advanced Energy—a North Carolina nonprofit that deals with applied building science—built 12 test houses with a variety of crawl space designs to determine which design worked best. The findings on its Web site are accompanied by videos and reports that can help a homeowner determine how to best improve their crawl space.

Finishing the crawl space area can be a large undertaking. Depending on its current state, the project may take weeks and cost thousands of dollars. But leaving the crawl space area a humid, musty and energy-inefficient hole in the ground can result in an unhealthy home, substructure damage and high utility costs. Proper encapsulation, ventilation blocking and crawl space conditioning will help green the home and keep the temperature, humidity and energy bills at a comfortable level year-round.

Text by Benjamin Hardy
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Technical Guidance to the Indoor airPLUS Construction Specifications

1. Moisture Control

Sections 1.1 - 1.4

Water-Managed Site and Foundation

- 1.1 Site and Foundation Drainage
- 1.2 Capillary Breaks
- 1.3 Damp-proof Foundation
- 1.4 Basements and Crawl Spaces

Sections 1.5 - 1.6

Sections 1.7 - 1.10

Sections 1.11 - 1.13

Sections 1.1 - 1.4: Water-Managed Site and Foundation

1.4 Basements and Crawl Spaces

**Insulate and condition basements and crawl spaces as follows:**

- Insulate crawl space and basement perimeter walls according to IRC Table N1102.1 or IECC Table 402.1.1 (also see Specification 1.12); AND
- Seal crawl space and basement perimeter walls to prevent outside air infiltration; AND
- Provide conditioned air at a rate not less than 1 cfm per 50 sq. ft. of horizontal floor area. If radon-resistant features are required (see Specification 2.1), do not install exhaust ventilation, as described in IRC section R408.3.2.1.

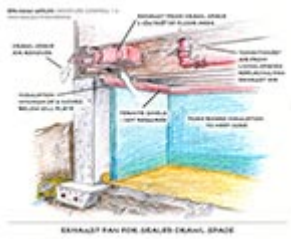
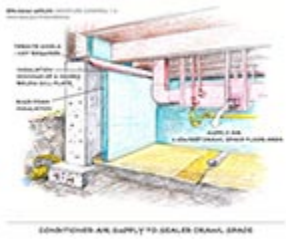
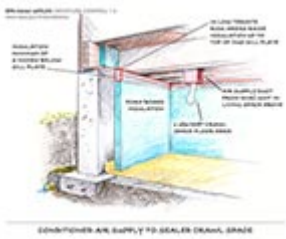
**Exceptions:**

- Homes built in areas designated as flood zones. (Conditioned crawl spaces are not recommended for use in flood zones.)
- Raised pier foundations with no walls.
- Dry climates, as defined by IECC Figure 301.1.
- Marine climates, as defined by IECC Figure 301.1, if no air handler or return ducts are installed in the crawl space.

**Note:** In each of the preceding exceptions, floors above unconditioned spaces shall be insulated to the IECC-specified R-value and sealed to prevent air infiltration.

Detailed Illustrations

Click on the image for a full-page version

| Exhaust fan for sealed crawlspace | Conditioned air supply to sealed crawlspace | Conditioned air supply to seal crawlspace |
|---|---|---|
|  |  |  |

Why

Please refer to the Construction Specifications 1.4 Insulate and condition basements and crawlspaces as follows:

Crawl spaces and basements can become moisture laden, supporting the growth of mold and the decay of building materials and providing ideal conditions for insect pests and even rodents. Moisture and contaminants can be driven into living spaces by the differences in air pressure between the crawl space/basement and the living spaces above. This exchange can be much greater when forced-air heating and air-conditioning equipment is located in basements and crawl spaces; the strong system airflows can pick up pollutants through any leak in the equipment, plenums or ductwork and quickly disperse them throughout the home.

Building codes traditionally have required the passive venting of crawl spaces to the outdoors, with the vent sizing dependent on the floor area of the crawl space and whether a vapor retarder such as polyethylene was present to reduce moisture entering the crawl space from the soil. However, research has shown that ventilating air entering the crawlspace from outdoors during warm, humid seasons wets rather than dries crawl spaces even if effective drainage and dampproofing systems are installed to keep liquid water out and a vapor retarder is in place on the earth floor.

However, conditioned crawl spaces have been shown to provide better moisture control, and they are more energy efficient. The International Residential Code (2009) provides for un-vented crawl spaces (R408.3). Conditioned crawl spaces have several essential elements:

- Perimeter walls (including an access door opening to the outside, if provided) that are sealed to prevent infiltration of outside air (no passive vents).
- Insulated walls to reduce the transfer of heat either into or out of the space.
- Floor covered with vapor-retardant membrane (with or without a concrete slab covering the vapor retarder) to control soil moisture (see Specification 1.2).
- Either mechanical exhaust ventilation or conditioned-air supply.
- Floor drains leading to daylight outdoors or to a sump pit.

In warmer weather, a sealed crawl space prevents warm air from entering through wall vents and condensing on surfaces cooled by the ground temperature inside the crawl space. Sealing also produces energy savings by preventing the loss of dryer conditioned air (or during winter months, warmer conditioned air) that has been supplied to the space.

How

Ventilation openings should not be installed in the crawl space walls (except when an active exhaust fan is located in the wall to provide mechanical ventilation, described below). In addition, the following locations must be air-sealed using caulks, adhesive, air-sealing foam, gaskets or adhesive membranes:

- Exterior entry hatches or doors.
- Joints between the top of the foundation wall and the mud sill, between the mud sill and the rim joist and between the rim joist and the sub-floor.
- Around ducts, pipe conduits or other penetrations through the wall or rim joist.

Foundation walls may be insulated on their outside, inside or, in the case of insulated concrete forms, both sides. Insulating on the outside keeps the foundation wall's temperature and moisture content more uniform throughout the year. If insulation is applied to the interior side of a basement wall, materials that can act as vapor barriers (e.g., polyethylene film, foil-faced paper or vinyl wall covering) should not be used (see Specification 1.12). The vapor barrier can trap any moisture present in the foundation wall, creating moisture and mold problems on the wall's interior surface.

Moisture and humidity issues are not eliminated once the crawl space is sealed. In the sealed environment, a small amount of moisture or humidity can cause a significant moisture problem unless provisions are made for some level of air exchange with conditioned air. This is accomplished with mechanical ventilation of the crawl space in essentially two ways:

- An exhaust fan inserted into the crawl space wall removes a small amount of air from the crawl space and it is replaced by drawing a small amount of conditioned air from the living space (through cracks and other openings in the floor above into the crawl space). If radon-resistant construction is necessary (see Specification 2.1), do not implement this option because it can interfere with the operation of the mitigation system.
- A small amount of conditioned air (minimum 1 cfm per 50 sq. ft. of crawl space floor area) is blown directly from the heating and air-conditioning system (from equipment located in the living space above and ducted to the crawl space, or directly from HVAC equipment located in the crawl space).

See also "Ventilation," (Specification 4.5) for general ventilation needs for the home.

**TABLE 322.32**

**STEEL−FRAME CEILING, WALL AND FLOOR INSULATION R−VALUES**

| Wood Frame R−Value Requirement | Cold−Formed Steel Equivalent R−Value[a] |
|---|---|
| Steel Truss Ceilings[b] | |
| R−30 | R−38 or R−30 + 3 or R−26 + 5 |
| R−38 | R−49 or R−38 + 3 |
| R−49 | R−38 + 5 |
| Steel Joist Ceilings[b] | |
| R−30 | R−38 in 2X4 or 2X6 or 2X8<br>R−49 in any framing |
| R−38 | R−49 in 2X4 or 2X6 or 2X8 or 2X10 |
| Steel Framed Wall | |
| R−13 | R−13 + 5 or R−15 + 4 or R−21 + 3 |
| R−19 | R−13 + 9 or R−19 + 8 or R−25 + 7 |
| R−21 | R−13 + 10 or R−19 + 9 or R−25 + 8 |
| Steel Joist Floor | |
| R−13 | R−19 in 2X6<br>R−19 + 6 in 2X8 or 2X10 |
| R−19 | R−19 + 6 in 2X6<br>R−19 + 12 in 2X8 or 2X10 |

[a] Cavity insulation R−value is listed first, followed by continuous insulation R−value.

[b] Insulation exceeding the height of the framing shall cover the framing.

**History:** CR 08−043: cr. Register March 2009 No. 639, eff. 4−1−09; correction in (3) (a), (b), (4) (a), (6) (b), (7) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

**SPS 322.33 Slab floors. (1)** HEATED OR UNHEATED SLABS. Any heated or unheated slab floor, the bottom of which is less than 12 inches below adjacent grade, shall be provided with perimeter insulation in accordance with Table 322.31−1 or Table 322.31−4.

**(2)** HEATED SLABS. In addition to meeting the requirement under sub. (1), if applicable, heated slab floors of any depth below grade shall meet the under−slab R−value requirement in accordance with Table 322.31−1 or Table 322.31−4.

**(3)** DETAILS. (a) The top edge of insulation installed between the exterior wall and the edge of the interior slab may be cut at a 45 degree angle away from the exterior wall.

(b) Horizontal insulation extending outside of the foundation shall be covered by soil a minimum of 10 inches thick or by pavement.

**Note:** See Appendix for further explanatory materials.

**History:** CR 08−043: cr. Register March 2009 No. 639, eff. 4−1−09; CR 09−104: am. (1), (2) Register December 2010 No. 660, eff. 1−1−11; correction in (1), (2) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

**SPS 322.34 Crawl spaces. (1)** FROST PROTECTION. If the bottom of the crawl space serving as the dwelling foundation is less than 48 inches below adjacent grade, the foundation shall be frost protected in accordance with Table 322.31−1 for frost protected slabs.

**(2)** VAPOR RETARDER. Any exposed earth in crawl spaces shall be covered with a continuous vapor retarder.

(b) All decayable organic material, including topsoil, shall be removed from crawl space floors prior to placing the vapor retarder.

(c) All joints of the vapor retarder shall overlap by 6 inches and be sealed or taped.

(d) The edges of the vapor retarder shall extend at least 6 inches up the foundation wall and shall be attached to the foundation wall.

**(3)** UNINSULATED CRAWL SPACES. (a) For crawl spaces that are outside of the thermal envelope, ventilation openings equal to at least 1/1500 of the floor space shall be provided.

(b) At least 50% of the ventilating area shall be provided at opposite sides of the crawl space or as far apart as possible.

(c) The floor above the crawl space shall be insulated in accordance with Table 322.31−1.

**(4)** INSULATED CRAWL SPACES. (a) As an alternative to insulating floors over unheated crawl spaces, crawl space walls shall be insulated in accordance with Table 322.31−1.

(b) Crawl space wall insulation shall be permanently fastened to the wall and shall extend the entire height of the wall.

(c) The crawl space may not be vented to the outside unless the floor above is insulated in accordance with Table 322.31−1.

**History:** CR 08−043: cr. Register March 2009 No. 639, eff. 4−1−09; correction in (1), (3) (c), (4) (a), (c) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

**SPS 322.35 Thermally isolated sunrooms. (1)** The minimum opaque ceiling insulation R−value shall be R−24. The minimum opaque wall R−value shall be R−13.

**(2)** The maximum fenestration U−factor shall be 0.50 and the maximum skylight U−factor shall be 0.75.

**(3)** New walls, windows and doors separating a sunroom from conditioned space shall meet the building thermal envelope requirements.

**(4)** The temperature in the conditioned space shall be controlled as a separate zone or shall use separate heating equipment.

**(5)** Glazing in a thermally−isolated sunroom is not considered to be in the dwelling thermal envelope.

**History:** CR 08−043: cr. Register March 2009 No. 639, eff. 4−1−09.

**SPS 322.36 Fenestration. (1)** AVERAGE U−FACTORS. An area−weighted average of fenestration products may be used to satisfy the U−factor requirements.

**(2)** MAXIMUM FENESTRATION U−FACTOR. The area weighted average maximum fenestration U−factor permitted using trade offs from s. SPS 322.31 (2) or subchapter VI shall be 0.40 for vertical fenestration, and 0.75 for skylights.

**(3)** GLAZED FENESTRATION EXEMPTION. Up to 15 square feet of glazed fenestration per dwelling unit may be exempt from U−factor requirements of the chapter.

**(4)** OPAQUE DOOR EXEMPTION. One opaque door assembly is exempted from the U−factor requirements of this chapter.

**(5)** REPLACEMENT FENESTRATION. Where an existing fenestration unit is replaced with a new fenestration unit, including sash and glazing, the replacement unit shall meet the U−factor requirements of this chapter.

**(6)** CERTIFIED PRODUCTS. Except as provided in sub. (7), fenestration rating, certification and labeling of U−factors for windows, doors and skylights shall be in accordance with NFRC 100.

**(7)** DEFAULT VALUES. When a manufacturer has not determined product U−factor in accordance with NFRC 100, U−factors shall be determined by assigning a default value in accordance with Tables 322.36−1 and 322.36−2. Where a composite of materials of two different product types is used, the product shall be assigned the higher U−factor.

**R406.4 Precast concrete foundation system dampproofing.** Except where required by Section R406.2 to be waterproofed, precast concrete foundation walls enclosing habitable or useable spaces located below *grade* shall be dampproofed in accordance with Section R406.1.

**R406.4.1 Panel joints sealed.** Precast concrete foundation panel joints shall be sealed full height with a sealant meeting ASTM C 920, Type S or M, *Grade* NS, Class 25, Use NT, M or A. Joint sealant shall be installed in accordance with the manufacturer's installation instructions.

## SECTION R407
## COLUMNS

**R407.1 Wood column protection.** Wood columns shall be protected against decay as set forth in Section R317.

**R407.2 Steel column protection.** All surfaces (inside and outside) of steel columns shall be given a shop coat of rust-inhibitive paint, except for corrosion-resistant steel and steel treated with coatings to provide corrosion resistance.

**R407.3 Structural requirements.** The columns shall be restrained to prevent lateral displacement at the bottom end. Wood columns shall not be less in nominal size than 4 inches by 4 inches (102 mm by 102 mm). Steel columns shall not be less than 3-inch-diameter (76 mm) Schedule 40 pipe manufactured in accordance with ASTM A 53 Grade B or *approved* equivalent.

**Exception:** In Seismic Design Categories A, B and C, columns no more than 48 inches (1219 mm) in height on a pier or footing are exempt from the bottom end lateral displacement requirement within under-floor areas enclosed by a continuous foundation.

## SECTION R408
## UNDER-FLOOR SPACE

**R408.1 Ventilation.** The under-floor space between the bottom of the floor joists and the earth under any building (except space occupied by a *basement*) shall have ventilation openings through foundation walls or exterior walls. The minimum net area of ventilation openings shall not be less than 1 square foot (0.0929 $m^2$) for each 150 square feet (14 $m^2$) of under-floor space area, unless the ground surface is covered by a Class 1 vapor retarder material. When a Class 1 vapor retarder material is used, the minimum net area of ventilation openings shall not be less than 1 square foot (0.0929 $m^2$) for each 1,500 square feet (140 $m^2$) of under-floor space area. One such ventilating opening shall be within 3 feet (914 mm) of each corner of the building.

**R408.2 Openings for under-floor ventilation.** The minimum net area of ventilation openings shall not be less than 1 square foot (0.0929 $m^2$) for each 150 square feet (14 $m^2$) of under-floor area. One ventilation opening shall be within 3 feet (915 mm) of each corner of the building. Ventilation openings shall be covered for their height and width with any of the following materials provided that the least dimension of the covering shall not exceed $^1/_4$ inch (6.4 mm):

1. Perforated sheet metal plates not less than 0.070 inch (1.8 mm) thick.
2. Expanded sheet metal plates not less than 0.047 inch (1.2 mm) thick.
3. Cast-iron grill or grating.
4. Extruded load-bearing brick vents.
5. Hardware cloth of 0.035 inch (0.89 mm) wire or heavier.
6. Corrosion-resistant wire mesh, with the least dimension being $^1/_8$ inch (3.2 mm) thick.

**Exception:** The total area of ventilation openings shall be permitted to be reduced to $^1/_{1,500}$ of the under-floor area where the ground surface is covered with an *approved* Class I vapor retarder material and the required openings are placed to provide cross ventilation of the space. The installation of operable louvers shall not be prohibited.

**R408.3 Unvented crawl space.** Ventilation openings in under-floor spaces specified in Sections R408.1 and R408.2 shall not be required where:

1. Exposed earth is 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 at least 6 inches (152 mm) up the stem wall and shall be attached and sealed to the stem wall or insulation; and
2. One of the following is 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 crawlspace 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 N1103.2.1 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 of this code;
   - 2.3. Plenum in existing structures complying with Section M1601.5, if under-floor space is used as a plenum.

**R408.4 Access.** Access shall be provided to all under-floor spaces. Access openings through the floor shall be a minimum of 18 inches by 24 inches (457 mm by 610 mm). Openings through a perimeter wall shall be not less than 16 inches by 24 inches (407 mm by 610 mm). When any portion of the

through-wall access is below *grade*, an areaway not less than 16 inches by 24 inches (407 mm by 610 mm) shall be provided. The bottom of the areaway shall be below the threshold of the access opening. Through wall access openings shall not be located under a door to the residence. See Section M1305.1.4 for access requirements where mechanical *equipment* is located under floors.

**R408.5 Removal of debris.** The under-floor *grade* shall be cleaned of all vegetation and organic material. All wood forms used for placing concrete shall be removed before a building is occupied or used for any purpose. All construction materials shall be removed before a building is occupied or used for any purpose.

**R408.6 Finished grade.** The finished *grade* of under-floor surface may be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished floor at the building perimeter or where there is evidence that the surface water does not readily drain from the building site, the *grade* in the under-floor space shall be as high as the outside finished *grade*, unless an *approved* drainage system is provided.

**R408.7 Flood resistance.** For buildings located in flood hazard areas as established in Table R301.2(1):

1. Walls enclosing the under-floor space shall be provided with flood openings in accordance with Section R322.2.2.
2. The finished ground level of the under-floor space shall be equal to or higher than the outside finished ground level on at least one side.

   **Exception:** Under-floor spaces that meet the requirements of FEMA/FIA TB 11-1.