



## **Building Guidance for Healthy Homes**

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The Asthma Regional Council (ARC) of New England is committed to reducing the impact of asthma on children and families across New England through the collaboration of health, housing, education and environmental organizations. ARC is a coalition of public agencies, private organizations and researchers all working together to address the environmental contributors to asthma.

Modifications in current housing construction and maintenance practices can help minimize conditions that are associated with asthma and asthma triggers. This guidance presents the general principles to help achieve healthier indoor environments, recommends specific building practices, and describes technical resources to support the adoption of these healthy building practices. This document updates the original ARC Guidance of April 2002 to incorporate additional practices to reduce moisture and allergens, particularly in below grade spaces. Many of the additional practices were drawn from the U.S Environmental Protection Agency's Energy Star Indoor Air Package, September 2005. This Guidance was prepared by ARC's Senior Advisor, Ellen Tohn, ERT Associates and benefited from input and suggestions provided by the ARC Healthy Housing Committee. A list of committee members is available at [www.asthmaregionalcouncil.org](http://www.asthmaregionalcouncil.org).

## **Background**

The number of children diagnosed with asthma has doubled in the past 15 years. Asthma rates in the Northeast are among the highest in the country, 13.9% of children report that they have had asthma during their lifetime compared with the national average of 12.4%. Lifetime asthma rates for adults in New England also exceed the national average with 15% of adults reporting asthma during their lifetime; the national average is 13%. Asthma is an allergic reaction to certain exposures ("triggers") such as dust, moisture/mold, pests (cockroaches, rats, mice), pets (cats and dogs), cold air, and dry heat.

This guidance presents principles and specific construction practices designed to minimize residential exposures to asthma triggers. Many of these practices also improve energy efficiency and are consistent with green building practices. ARC encourages state housing, finance, environmental and health agencies as well as non-governmental organizations and business involved in developing and maintaining housing to implement these building practices, whenever feasible.

## **Seven Healthy Homes Principles**

**Dry:** Reducing moisture minimizes mold growth and makes it difficult for pests to thrive. Living in moist and mold conditions is associated with increased risk of asthma.

**Clean:** Dust mites can cause allergic reactions triggering asthma attacks. Clutter and debris make it difficult to remove dust mites and other allergens in dust. Dust can also be a breeding grounds for pests.

**Well Ventilated:** Ventilation moves air to help reduce excess humidity and airborne contaminants. Spot ventilation exhausts humidity and contaminants from specific sources (bathroom showers, kitchen cooking) minimizing mold. Dilution ventilation deals with low-level contamination throughout the home.

**Combustion By-Product Free:** Combustion products such as carbon monoxide have adverse health consequences that in extreme cases can result in death.

**Pest Free:** Pests' droppings can cause allergic reactions which may trigger asthma attacks. Misuse of pesticides to address pest infestations may also create adverse health effects.

**Toxic Chemical Free:** Containers storing cleaning compounds, pesticides, oil- or alkyd-based paints and solvents can release toxics to the indoor air and exacerbate asthma.

**Comfortable:** Uncomfortable homes can spur residents to take actions that make a home unhealthy. If people are cold, they won't ventilate their home. If people are dry or hot, they will often open windows and/or add moisture (humidify) to the point of producing mold.

## **Recommended Building Practices to Achieve Healthier Homes**

While there is no recipe that can guarantee a healthy home, the recommended building practices presented here will help create healthier indoor environments. We list the practices under three categories that group the principles. The principle of "comfort" is inherent in each category

- Dry and Clean

- Well Ventilated and Free of Combustion Products and Toxics
- Pest Free

Each home construction and each rehabilitation project presents unique constraints and opportunities. The measures included here were chosen because the opportunities to use them occur frequently and they are feasible for most construction and rehab projects. These measures may need minor adjustments in specific situations, particularly for projects involving the rehabilitation of existing buildings. Therefore, on-going training in healthy homes principles and access to technical consultations for project designers and builders is critical. Resources for such assistance are described later in this guidance.

An **R** or **C** follows the description of each practice and denotes whether it is appropriate for renovation and/or new construction. The italicized text explains the rationale for the recommended practice where added description is appropriate.

A reference to the key resource document used to develop these recommendations is provided to give users a citation for additional detail and specifications. The pages referenced in italics refer to the pamphlet -- *Healthy and Affordable Housing: Practical Recommendations for Building, Renovating and Maintaining Housing - READ THIS Before You Design, Build or Renovate (READ THIS), May2005*. This is one of a series of three pamphlets developed by Building Science Corporation for training sponsored by the ARC, U.S. Department of Housing and Urban Development, and U.S. Department of Energy's Building America Program. The other two pamphlets provide recommendations "Before You Turn Over a Unit" and "Before You Move In." The pamphlets are available on the Building Science website [www.buildingscience.com](http://www.buildingscience.com) and ARC website [www.asthmaregionalcouncil.org](http://www.asthmaregionalcouncil.org). ARC recommends that individuals and organizations consult these pamphlets when developing and revising building standards and practices. The pamphlets include the practices listed here and a broader array of recommendations that will help improve the overall health conditions for occupants. Additional references are also provided, where appropriate, to the International Residential Code (IRC).

## Dry and Clean Structures

### Below Grade - Foundations

1. Install capillary breaks at all concrete slabs. Use 4 inch bed of ½ inch diameter or greater clean or washed gravel, covered with a minimum 6 mil. polyethylene sheeting lapped minimum of 12 inches at joints or an equivalent system. Alternately, use a minimum 4 inch uniform layer of sand, overlain with a layer or strips of geotextile drainage matting, covered with polyethylene sheeting lapped a minimum of 12 inches at joints. C

*Capillary breaks help to minimize the movement of moisture from the ground up through the concrete slab. [READ THIS, Figure 8a-c: Groundwater control with basements, crawlspaces, and slabs, pp. 10-11; IRC, Appendix F, AF103.3 Soil Gas Retarder; IRC, Table R405.1, Unified Soil Classification System; IRC R506.2.3, Vapor Retarder]*

2. Install a capillary break on top of the footing between the footing and the perimeter foundation wall. C

*A break helps minimize movement of moisture from the ground into the building assemblies. [READ THIS, Figures 8a, 8b, 8c: Groundwater controls, Figure 10: Capillary rise through basement footing, Figure 11: Capillary break over footing, Figure 12: Capillary control for monolithic slab, pp.11-13]*

3. Manage rainwater and surface water. R & C

- Gutters and downspouts should empty to lateral piping that deposit(s) water on finish grade a minimum of 5 ft. from foundation, or in limited spaces, deposit to underground catchment system that carries water 10 ft. from foundation.
- Final grade shall be back-fill tamped to accommodate settling and slope away from the foundation ½ inch per foot within the first 10 feet. Use swales, drains or other methods where there is insufficient space to meet the recommended grade. Slope patio slabs, walks and driveway ¼ inch per foot away from house.
- Slope garage floor toward main vehicle entry doorway min. 1/8 inch per foot.

*Gutters, downspouts, and exterior grading help to manage rain and surface water directing water away from the structure. [READ THIS, Figure 22 :Internally insulated concrete basement with wood siding above, Figure 23: Internally insulated concrete crawlspace with stucco wall above, pp. 18, 20; IRC Code 801.c and R309.3]*

### Below Grade – Basements & Crawl Spaces

1. Provide drain tile for all basement or crawl space footings, level or sloped to discharge to outside grade (daylight) or to accessible sump pump. Top of drain tile pipe must always be below level of where bottom of concrete slab or crawl space grade will occur. Pipe shall be surrounded with min. 6 inch of ¾ inch washed or clean gravel that is fully wrapped with fabric cloth. C

*This helps to direct water away from the footing where moisture can enter the structure. [READ THIS, Figure 10: Capillary break over footing, p. 11]*

2. Insulate basement and crawl space walls with International Energy Conservation Code (IECC) specified R-value; do **not** install a vapor barrier on interior or living space side of wall (note that semi-vapor permeable rigid insulation is not considered a vapor barrier). Many systems meet this specification, three examples are listed below.

- Exterior foam board to meet the code.
- Interior foam board to meet the energy code, providing covering to address flammability issues (e.g., gypsum providing an air gap with furring strips, stud wall or alternative; or foil faced foam).
- Combination foam board up against the foundation wall, fiberglass insulation in a stud wall.

Follow restrictions in IRC R320.4 of the International Residential Code (“Termite protection and prohibition of foam plastics”) for added guidance on the use of foam on foundation exteriors. **C**

*Insulating foundation walls helps to prevent condensation on walls that can form during warm seasons. Vapor barriers installed on the interior wall can trap moisture in wall systems. [READ THIS, Figure 22: Internally insulated concrete basement with wood siding above, p.18; IRC Section R320.4]*

3. Crawl spaces shall be unvented and conditioned. Crawl space floor shall be one of the below. **C**

- Soil covered with 6 mil. polyethylene (10 mil. recommended) lapped 12 inches and attached to walls and piers with adhesive and furring strips; or
- Concrete slab over lapped polyethylene and gravel.

Crawl space shall be fully sealed to prevent outside air infiltration and be provided with supply air at a rate not less than 0.02 cfm per square foot of horizontal area and an equal size exhaust opening to the conditioned space. In areas prone to flooding, sealed crawl spaces should not be used.

*Polyethylene helps prevent water vapor from entering the crawl space. Once sealed, it is important to provide a small amount of conditioned air to avoid high humidity which can create moisture problems. [READ THIS, Figure 26: Connecting Crawl Spaces and Basements, Figure 27: Conditioning Crawlspace, pp.22-23]*

## Wall Systems and Flooring

1. Fully flash all window and door openings, including pan flashing at sills, side flashing that extends over pan flashing and top flashing that extends over side. Apply window pan flashings over building paper at sill and corner patches. **R & C**  
*Flashing helps direct water away from wall cavities and to the drainage plane.*  
*[READ THIS, Figure 3: Installing window with housewrap on OSB over a wood frame wall, Figure 4: Flashing over and under window trim; pp.5-7]*
2. Provide step flashing at all intersections of roof and walls with the exception of continuous flashing at metal and rubber membrane roofs. Metal “kick-out” flashing shall be provided at the end of roof/wall intersections to direct water away from wall. Drainage plane above shall be direct water flow onto and not behind flashing. **R & C**  
*Flashing helps direct water away from the building and prevents water from entering the structure.*
3. Avoid putting plumbing in exterior walls. **R & C**  
*It is easier to detect and repair leaks in interior walls. [READ THIS, Figure 17: Locating plumbing pipes, p.15]*
4. Install hot water heaters in rooms with drains or catch pans and floor coverings that are not water sensitive. Install easy to use shut off valves for clothes washers and hot water heaters. **R & C**  
*These precautions will minimize damage from leaks.*
5. Use cement board, fiber cement board, or cement plaster as an air barrier in wet areas such as behind tubs or showers. **R & C**  
*Do not use paper-faced gypsum board that can wick moisture. [READ THIS, Figure 28c: Section of tub framing, p.24]*
6. Seal all plumbing, electrical, and other penetrations of walls and floors, and joints between building materials with polyurethane caulk (e.g., utility walls where they intersect exterior walls and ceiling). Seal bathtub and shower enclosures with rigid materials (e.g. sheathing or gypsum board). **R & C**  
*This minimizes airflow that can bring in moisture and pests. [READ THIS, Figure 28: Tub framing, Figure 29: Utility Chase construction, pp.24-25]*
7. Insulate cold water pipes in unconditioned spaces. **R & C**  
*Insulation minimizes condensation in warm temperatures. [READ THIS, p.28]*
8. Install continuous drainage plane fully sealed at all penetrations that directs water way from all wall assemblies with either: **C**
  - Monolithic weather resistant barrier (e.g., house wrap) sealed or taped at all overlap joints, top, and bottom

- Weather resistant sheathings (e.g., faced rigid insulation) fully taped at all “butt” joints, or
- Lapped shingle-style building paper or felts.

*Drainage planes provide a pathway for water to run away from the structure and avoid creating reservoirs behind cladding. [READ THIS, Figure 6: Ventilated cavity, Figure 7: Drained cavity with condensing surface, Figure 12: Interior drainage – new construction, pp.8, 12]*

9. Backprime exterior siding materials (paint back, front, edges and ends of wood siding, cement siding and wood trim). **C**

*This helps prevent wood clapboard from absorbing moisture and eliminates a potential water reservoir. [READ THIS, p.8]*

10. Do not install carpet in wet areas (e.g., bathrooms, laundry rooms, kitchens, entryways, and damp basements). Use smooth and cleanable surfaces that do not act as reservoirs for moisture/mold and can be washed (e.g., vinyl, wood, tile, rubber). Whenever possible, install smooth and washable surfaces in other rooms/areas (e.g., common areas, bedrooms, living rooms). When possible, provide at least one bedroom without carpet. **R & C**

*Carpet can trap moisture and dust. They can become a breeding ground for mold. Smooth and cleanable surfaces do not trap moisture and are easier to clean. [READ THIS, p.34]*

### **Attics**

1. Avoid putting duct work and air handlers in attics because of air leakage. **R & C**  
*[READ THIS, p.30]*

### **Well Ventilated and Free of Combustion Products and Toxics**

1. Install exterior exhausting fans in bathrooms and kitchens. Use ENERGY STAR bath fans. If available use ENERGY STAR kitchen fans. **R & C**

*Fans exhaust excess humidity that can spur moisture and/or mold issues. [READ THIS, Figure 36: Exhaust ventilation system with point source exhaust, p.29]*

2. Install power vented fans or range hoods that exhaust to the exterior when gas cook tops and gas ovens are present. **R & C**

*These fans remove moisture, odors and other contaminants. [READ THIS, Figure 32: Exhaust ventilation system with point source exhaust, p.29]*

3. Seal forced air ductwork, particularly on the return side (suction side). R & C  
*This helps avoid negative air pressures that can draw contaminants (radon and soil gas) into homes from below grade or smoke and odors from neighboring units.*  
[READ THIS, Figure 39: Air Handler Sealing; p.30]
4. Ventilate attics at the soffits and ridges. C  
*This helps to control moisture problems.* [READ THIS, Figure 35: Baffle installation, p.27]

## **Pest Free**

1. Seal utility openings and joints between openings. Avoid materials that rodents can chew. Use corrosion proof materials (e.g., copper or stainless steel mesh). R & C  
*Reducing holes minimizes transit pathways for rodents and pests.* [READ THIS, Figure 29: Utility chase construction, p.25]
2. Seal utility openings and joints between materials. R & C  
*This minimizes transit pathways for pests.* [READ THIS, p.35]

## **Training and Technical Assistance**

Training and technical assistance are critical to implementing the changes in building practices advocated in this guidance. Housing policy makers, designers, project management staff, and contractors must understand the connections between building construction practices, indoor air quality and asthma and have the practical knowledge to apply healthy home concepts to their own housing projects.

We strongly urge that whenever possible employees involved in designing, constructing, and maintaining publicly funded housing complete relevant training. A list of organizations that provide and/or sponsor such training and technical assistance is provided below.

## **Government**

U.S. Environmental Protection Agency  
Office of Air and Radiation  
ENERGY STAR Buildings Program & Indoor Environments Division  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460  
888.STAR-YES [www.epa.gov/iaq](http://www.epa.gov/iaq) & [www.energystar.gov](http://www.energystar.gov)  
(publications)

U.S. Department of Housing & Urban Development  
Office of Healthy Homes and Lead Hazard Control

451 Seventh Street, SW Room P-3206  
Washington, DC 20410  
202-755-1785 [www.hud.gov/offices/lead](http://www.hud.gov/offices/lead)  
(publications)

U.S. Department of Energy, Building America Program  
1000 Independence Ave., SW  
Washington, DC 20585  
800.dial.DOE [www.eren.doe.gov/buildings/building\\_america](http://www.eren.doe.gov/buildings/building_america)  
(publications, technical assistance, training)

## **Non Profit**

Affordable Comfort  
32 Church Street,  
Suite 204  
Waynesburg, PA 15370  
724-627-5200 <http://www.affordablecomfort.org/home1.html>  
(training, conferences, publications)

Alliance for Healthy Housing  
227 Massachusetts Avenue, NE  
Washington, DC 20002  
202-543-1147 [www.afhh.org](http://www.afhh.org)  
(Publications)

American Lung Association, Health House® Program  
490 Concordia Avenue  
St. Paul, MN, 55103-2441  
(877) 521-1791, (800) 642-5864 within MN [www.healthhouse.org](http://www.healthhouse.org)  
(Publications, training)

Energy & Environmental Building Association  
10740 Lyndale Avenue South, Suite 10W  
Bloomington, MN 55420-5615  
952.881.1098 [www.eeba.org](http://www.eeba.org)  
(Publications, training, conferences)

Maine Indoor Air Quality Council  
PO Box 2438  
Augusta, ME 04338-2438  
207.626.8115 [www.miaqc.org](http://www.miaqc.org)  
(Publications, training)

The National Center for Healthy Housing

10227 Wincopin Circle  
Columbia, Maryland 21044  
410-992-0712 [www.centerforhealthyhousing.org](http://www.centerforhealthyhousing.org)  
(Publications, training, clearinghouse)

Rocky Mountain Institute  
1739 Snowmass Creek Road  
Snowmass CO 81654-9199  
970. 927.3851 [www.greendesign.net](http://www.greendesign.net)  
(publications)

## **Other Building Science Resources**

Building Science Corporation  
70 Main Street  
Westford, MA 01886  
978.589.5100 [www.buildingscience.com](http://www.buildingscience.com)  
(Publications, training, technical assistance, design)

Terry Brennan, Camroden Inc.  
724 East Carter Road  
Westmoreland, NY 13490  
315.336.7955 [terry@camroden.com](mailto:terry@camroden.com)  
(Training, technical assistance, building diagnostics)

Bill Turner  
Turner Building Science, LLC  
26 Pinewood Lane  
Harrison, Maine 04040-4334  
207-583-4571 [www.hturner.com](http://www.hturner.com)  
(Training, technical assistance, engineering design, building diagnostics)

## **Technical Resources**

### **Healthy and Affordable Housing: Practical Recommendations for Building Renovation and Maintaining Housing:**

- **Before You Design, Build or Renovate**
- **Before You Turn Over a Unit**
- **Before You Move In**

Building Science Inc. developed these three pamphlets for training sponsored by the Asthma Regional Council, US Department of Housing and Urban Development, and US Department of Energy's Building America Program. The pamphlets are available

electronically at [www.buildingscience.com](http://www.buildingscience.com). The Before you Design, Build or Renovate pamphlet is also available at [www.asthmaregionalcouncil.org](http://www.asthmaregionalcouncil.org).

**Energy and Environmental Building Association's Builder's Guides (EEBA Guide).**

The Department of Energy's Building America Program developed these Guides which provide useful technical details to address moisture control and energy issues. Copies are available from Environmental and Energy Building Association, 10740 Lyndale Avenue South, Suite 10W, Minneapolis, MN 55420 952.881.1098 [www.eeba.org](http://www.eeba.org).

**U.S. Environmental Protection Agency, ENERGY STAR Indoor Air Package Specifications**

EPA has developed an add on package for its existing ENERGY STAR criteria to address indoor air quality issues. [www.epa.gov/iaq](http://www.epa.gov/iaq). As of July 2006, the specifications were posted at

[www.energystar.gov/ia/partners/bldrs\\_lenders\\_raters/downloads/IAQ\\_Specification\\_093005.pdf](http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/IAQ_Specification_093005.pdf).