Continuous Air Barrier in Exterior Walls

Last Updated: 03/14/2016

Scope

Ensure that a continuous air barrier exists around the entire thermal envelope of the home and that the air barrier is in full contact with the insulation.

- Identify on house plans what materials will constitute the air barrier in all components of the home’s thermal envelope including the walls, floors, and ceiling.
- Install the continuous air barrier which could consist of one or a combination of any of the following air barrier materials:
  - rigid materials like foam board insulation, drywall, plywood, or OSB
  - flexible materials like house wrap, with all seams and edges sealed and with the house wrap supported using approved fasteners (don't use kraft paper or other materials that tear easily)
  - fluid-applied membranes like liquid membranes, which are applied with a paint brush, roller, or sprayer over the sheathing
  - spray foam – if used as the air barrier it should be at least 5.5 inches thick if open-cell or at least 1.5 inches thick if closed-cell spray foam insulation.
- Seal all seams, gaps, and holes in the air barrier.
- ENERGY STAR requires that an air barrier be installed at the exterior vertical surface of the wall insulation in all climate zones and also that an air barrier be installed at the interior vertical surface in Climate Zones 4-8. For ceilings, ENERGY STAR permits the air barrier to be at the interior or exterior horizontal surface in IECC Climate Zones 1-3 and at the interior horizontal surface in Climate Zones 4-8 (ENERGY STAR 2015).

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
The walls, floors, and roof/ceiling compose the physical shell of the home, also called the building enclosure or building envelope. Within these assemblies are components that comprise the home’s thermal envelope (insulation) and air barrier (sometimes referred to as the thermal boundary and pressure boundary). The air barrier layer or layers prevent the unwanted entry of outside air and escape of inside air. Code requires, and best practice dictates, that the home’s thermal layer of insulation be fully aligned with (in full continuous contact with) the home’s continuous air barrier (see 2009, 2012, and 2015 IRC). The home’s thermal barrier of insulation must also be continuous for best performance. It should be installed without misalignments, compressions, gaps, or voids. See the guide Insulation Installation Achieves RESNET Grade 1 for more installing insulation.

The air barrier can consist of any durable solid material that blocks air flow between conditioned space and unconditioned space, for example drywall, OSB, or rigid foam insulation can serve as an air barrier. While ENERGY STAR recommends rigid air barriers, flexible air barriers such as house wrap are acceptable if they are fully sealed at all seams and edges and supported using approved fasteners. For the air barrier to be continuous, any seams between sheets of material, or joints between one material and another, or holes must be sealed with a long-lasting air-sealing material. For example, seams in plywood or OSB can be caulked, seams in rigid foam can be sealed with compatible tapes, joints between drywall and framing can be sealed with caulk or spray foam, gaps around windows can be sealed with foam rods, spray foam, and self-adhesive flashing, holes around piping, wiring, or electrical boxes can be sealed with caulk, spray foam, or gaskets. Some exterior wall assemblies require additional air sealing details as described in the following guides: Walls behind Showers and Tubs, Staircase Walls, Walls behind Fireplaces, Attic Knee Walls, Skylight Shaft Walls, Walls Adjoining Porch Roof, Air Sealing Attached Garage, and Double Walls.

The air barrier may be installed on the interior side of the insulation, the exterior side of the insulation, or both, depending on the building component and the climate. For example, according to the ENERGY STAR Rater Field Checklist, in ceilings in IECC Climate Zones 1-3, the air barrier can be aligned with either the interior or exterior horizontal surface of the insulation but, in Climate Zones 4-8, it must be aligned with the interior horizontal surface of the ceilings (i.e., mudded, taped drywall). In walls, the air barrier (e.g., OSB or rigid foam sheathing) should be aligned with the exterior vertical surface of the insulation in all climate zones and also at the interior vertical surface of the wall insulation (the drywall) in Climate Zones 4-8. Regarding floors, the air barrier should be aligned with the exterior vertical surface of the insulation (at the rim joists) in all climate zones and if the floor is over unconditioned space, the subfloor must be aligned with the interior horizontal surface of the floor insulation (i.e., the insulation must be touching the subfloor above it, for example by installing batt insulation with metal staves or twine that will keep the batts up against the floor above).

While the thermal envelope (the insulation) is easy to see, it is sometimes difficult to determine what components comprise the air barrier, especially where one building component meets another, such as at rim joists. This is a problem because, to be effective, the air barrier must be continuous around the entire building envelope. This can be addressed at the design stage by making a copy of the plans and drawing or highlighting the components that will form the air barrier in each subassembly. See Figure 1.

Figure 1. Identify what components comprise the home's air barrier to ensure that the air barrier is consistent around walls, foundation, and ceiling.

How to Install a Continuous Air Barrier
1. Determine the location of the air barrier in the ceilings, walls, and floors, and specify it on the house plans. According to ENERGY STAR requirements, the air barrier location is based on the home's climate zone location:
   * Ceilings - At interior or exterior horizontal surface of ceiling insulation in Climate Zones 1-3; at interior horizontal surface of ceiling insulation in Climate Zones 4-8.
   * Walls - At exterior vertical surface of wall insulation in all climate zones; and also at interior vertical surface of wall insulation for Climate Zones 4-8.
   * Floors - At exterior vertical surface of wall insulation in all climate zones; and, if over unconditioned space, also at interior horizontal surface with supports to ensure alignment.

2. Install the air barrier and ensure that it is continuous across all components of the thermal envelope (see Figure 2 for an example of continuous air sealing). An air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams and adequate support to resist positive and negative pressures without displacement or damage. ENERGY STAR Certified Homes recommends, but does not require, rigid air barriers. ENERGY STAR specifies that open-cell foam have a finished thickness ≥ 5.5 inches and closed-cell foam have a finished thickness ≥ 1.5 inches to qualify as an air barrier, unless the manufacturer indicates otherwise. If flexible air barriers such as house wrap are used, they should be fully sealed at all seams and edges and supported using fasteners with caps or heads ≥ 1 inch in diameter, unless otherwise indicated by the manufacturer. Flexible air barriers should not be made of kraft paper, paper-based products, or other materials that are easily torn. If polyethylene is used, its thickness should be ≥ 6 mil. ENERGY STAR highly recommends, but does not require, inclusion of an interior air barrier at band joists in Climate Zone 4 through 8. All insulated vertical surfaces are considered walls (e.g., above- and below-grade exterior walls and knee walls) and must meet the air barrier requirements for walls, with the exception of adiabatic walls in multifamily dwellings. All insulated ceiling surfaces, regardless of slope (e.g., cathedral ceilings, tray ceilings, conditioned attic roof decks, flat ceilings, sloped ceilings), must meet the requirements for ceilings.

3. Air seal all seams, gaps, and holes in the air barrier. For example:
   * Use caulk and approved tape to seal seams in sheathing, subflooring, and drywall.
   * Use caulk and spray foam to seal gaps around wiring, piping, etc.
   * Cut pieces of rigid air blocking material like rigid foam or plywood and caulk in place to block larger air gaps.
   * Use caulk or putty to seal around electrical boxes or install boxes with built-in rubber gaskets.
   * Use sheet metal and fire-rated caulk to air seal around flues.

4. See the ENERGY STAR Rater Field Checklist, Thermal Enclosure System, 4. Air Sealing, for guides that provide specific air-sealing details.

Figure 2 - The air barrier is continuous across several components of the wall, including the foundation, rim joist, bottom plate, wall, window, and header.

How to Install a Continuous Thermal Barrier

1. Install the insulation and ensure that it is in full alignment with (in contact with) a continuous air barrier at the walls, floors, and ceilings. Take care to make the air barrier continuous by caulking at joints between wall components such as at rim joists; see Figure 3. Follow RESNET Grade I Insulation Installation Standards when installing the insulation. See the ENERGY STAR Rater Field Checklist, Thermal Enclosure System, 2. Fully-Aligned Air Barriers, for guides that provide specific insulation alignment details.

2. Install insulation at levels that meet or exceed code. If pursuing ENERGY STAR certification, insulation levels should meet or exceed the 2009 IECC requirements (Table 402.1.1). If pursuing DOE Zero Energy Ready Home certification, insulation levels should meet or exceed 2012 IECC requirements (Table 402.1.1). See the Compliance tab for additional information.
Figure 2 - The wall behind the fireplace is an exterior wall and requires a thermal barrier that is continuous with the rest of the wall’s insulation.
Ensuring Success

Verify with a visual inspection that a continuous air barrier exists to completely enclose the conditioned space of the house. Inspect that all seams, gaps, and holes in the air barrier are sealed with caulk, foam, or tape. Verify whole house air leakage with a blower door test. Visually inspect that all insulation levels meet or exceed 2009 IECC levels and achieve Grade I installation per RESNET standards.
Thermal Enclosure System.

2. Fully-Aligned Air Barriers. At each insulated location below, a complete air barrier is provided that is fully aligned as follows:
   - Walls: At exterior vertical surface of wall insulation in all climate zones; also at interior vertical surface of wall insulation in Climate Zones 4-8.

**DOE Zero Energy Ready Home (Revision 07)**

Exhibit 2 DOE Zero Energy Ready Home Target Home. The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Insulation and Infiltration) Whole house leakage must be tested and meet the following infiltration limits:

- Zones 1-2: \( \leq 3 \text{ ACH50} \);
- Zones 3-4: \( \leq 2.5 \text{ ACH50} \);
- Zones 5-7: \( \leq 2 \text{ ACH50} \);
- Zone 8: \( \leq 1.5 \text{ ACH50} \);
- Attached dwellings: \( \leq 3 \text{ ACH50} \).

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**IECC Climate Zones**

All of Alaska is in Zone 7 except for the following boroughs in Zone 8: Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks North Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope.

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands.
Training

Right and Wrong Images

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Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)

National Rater Field Checklist

Thermal Enclosure System.
2. Fully-Aligned Air Barriers.6 At each insulated location below, a complete air barrier is provided that is fully aligned as follows:
Walls: At exterior vertical surface of wall insulation in all climate zones; also at interior vertical surface of wall insulation in Climate Zones 4-8.8

Footnote 6) For purposes of this Checklist, an air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams and adequate support to resist positive and negative pressures without displacement or damage. EPA recommends, but does not require, rigid air barriers. Open-cell or closed-cell foam shall have a finished thickness ? 5.5 in. or 1.5 in., respectively, to qualify as an air barrier unless the manufacturer indicates otherwise. If flexible air barriers such as house wrap are used, they shall be fully sealed at all seams and edges and supported using fasteners with caps or heads ? 1 in. diameter unless otherwise indicated by the manufacturer. Flexible air barriers shall not be made of kraft paper, paper-based products, or other materials that are easily torn. If polyethylene is used, its thickness shall be ? 6 mil.

Footnote 8) All insulated vertical surfaces are considered walls (e.g., above- and below-grade exterior walls, knee walls) and must meet the air barrier requirements for walls. The following exceptions apply: air barriers recommended, but not required, in adiabatic walls in multifamily dwellings; and, in Climate Zones 4 through 8, an air barrier at the interior vertical surface of insulation is recommended but not required in basement walls or crawlspace walls. For the purpose of these exceptions, a basement or crawlspace is a space for which ? 40% of the total gross wall area is below-grade.

Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 1, Item 6) Certified under EPA Indoor airPLUS.

Exhibit 2 DOE Zero Energy Ready Home Target Home.
The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Insulation and Infiltration) Whole house leakage must be tested and meet the following infiltration limits:
- Zones 1-2: ? 3 ACH50;
- Zones 3-4: ? 2.5 ACH50;
- Zones 5-7: ? 2 ACH50;
- Zone 8: ? 1.5 ACH50;
- Attached dwellings: ? 3 ACH50.

Footnote 12) Building envelope assemblies, including exterior walls and unvented attic assemblies (where used), shall comply with the relevant vapor retarder provisions of the 2015 International Residential Code (IRC).
Footnote 23) Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol.

ASTM E1677-11

Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls. This specification covers minimum performances and specification criteria for an air barrier material or system for framed, opaque walls of low-rise buildings. The provisions are intended to allow the user to design the wall performance criteria and increase air barrier specifications for a particular climate location, function, or design.
2009 - 2018 IECC and IRC Minimum Insulation Requirements: The minimum insulation requirements for ceilings, walls, floors, and foundations in new homes, as listed in the 2009, 2012, 2015, and 2018 IECC and IRC, can be found in this table.

2009 IECC

Table R402.1.1 Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

Table 402.4.2 Air Barrier and Insulation Inspection Component Criteria. Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier are sealed. Air-permeable insulation is not used as a sealing material. Section R402.4.2 Air sealing and insulation is demonstrated by testing or visual inspection. Testing. The building should be tested for air leakage and should have an air leakage rate of ? 7 at rough-in.

2012 IECC

Table R402.1.1 Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

Table R402.4.1.1 Air Barrier and Insulation Installation, Table R402.4.1.1, Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier are sealed. Air-permeable insulation is not used as a sealing material.

Section R402.4.1.2 Testing. The building should be tested for air leakage and should have an air leakage rate of ? 5 in CZ 1 and 2 or ? 3 in CZ 3-8.

2015 and 2018 IECC

Table R402.1.2 Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

Table R402.4.1.1 Air Barrier and Insulation Installation, General requirements: A continuous air barrier is installed in the building envelope; breaks and joints in the air barrier are sealed. Air-permeable insulation is not used as an air-sealing material.

Section R402.4.1.2 Testing. The building should be tested for air leakage in accordance with ASTM E 779 or E 1827 (or RESNET/ICC 380 in 2018 IECC) and should have an air leakage rate of ? 5 in CZ 1 and 2 or ? 3 in CZ 3-8.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

2009 IRC

Table N1102.4.2 Air Barrier and Insulation Inspection Component Criteria. Table N1102.4.2, Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material.

2012 IRC

N1102.4.1.1 Air Barrier and Insulation Installation, Table N1102.4.1.1, Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material.

2015 and 2018 IRC

Table N1102.4.1.1 Air Barrier and Insulation Installation. General requirements: A continuous air barrier is installed in the building envelope; breaks and joints in the air barrier are sealed. Air-permeable insulation is not used as an air-sealing material.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.
Case Studies

1. Building America Case Study Technology Solutions for Existing Homes: Bedford Farmhouse High Performance Retrofit Prototype
   Author(s): BSC
   Organization(s): BSC
   Publication Date: July, 2010
   Case study describing project conducted by Habitat for Humanity of Greater Lowell (HfHGL) and Building Science Corporation (BSC).

2. Building America Case Study Technology Solutions for Existing Homes: Concord Four Square Retrofit
   Author(s): BSC
   Organization(s): BSC
   Publication Date: July, 2012
   Case study of a Concord four-square home retrofitted by Building Science Corporation in Massachusetts.

3. Building America Efficient Solutions for New Homes: Case Study: Concord Cape Prototype
   Author(s): BSC
   Organization(s): BSC
   Publication Date: July, 2010
   Case study of a Concord Cape Cod style home began in August 2008 by architects and engineers at Building Science Corporation, who developed the drawing set and specifications for the high performance custom home to be built in Concord, Massachusetts.

4. Building America Efficient Solutions for New Homes: Case Study: Habitat for Humanity Cold Climate High R-Value Prototype
   Author(s): BSC
   Organization(s): BSC
   Publication Date: July, 2010
   Habitat for Humanity of Greater Lowell bought the land on which to build the Westford House from the town of Westford for $1. Habitat then partnered with Building Science Corporation, the community, local and national manufacturers, distributors and donors in an effort to create a comfortable, healthy, durable and energy efficient single...

References and Resources*

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. 2009 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.
2012 IECC - International Energy Conservation Code
Author(s): International Code Council
Organization(s): ICC
Publication Date: January, 2012
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. 2012 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: January, 2012
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. 2015 IECC - International Energy Conservation Code
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6. 2015 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

8. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

9. Air Barriers - Airtight Drywall Approach
Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: May, 2009
Brochure about creating an air barrier by sealing drywall assemblies.

10. Air Barriers - Tub, Shower and Fireplace Enclosures
Author(s): Building Science Corporation
Organization(s): Building Science Corporation
Publication Date: May, 2009
Brochure about creating an air barrier at tub, shower and fireplace walls.

11.
12. Ceilings and Attics
Author(s): Southface Energy Institute, Oak Ridge National Laboratory
Organization(s): Southface Energy Institute, ORNL
Publication Date: February, 2000
Information sheet with information about insulating and ventilating attics.

13. DOE Zero Energy Ready Home National Program Requirements (Rev. 07)
Author(s): U.S. Department of Energy
Organization(s): DOE
Publication Date: May, 2019
Standard requirements for DOE’s Zero Energy Ready Home national program certification.

14. ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09) National Program Requirements
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: September, 2018
Webpage with links to documents providing the program requirements and checklists for ENERGY STAR Certified Homes (Ver. 3/3.1, Rev. 09).

15. Georgia State Supplements and Amendments to the International Energy Conservation Code
Author(s): Georgia Department of Community Affairs
Organization(s): Georgia Department of Community Affairs
Publication Date: January, 2011
Georgia state’s minimum standard energy code, including state supplements and amendments.

16. Sealing Air Barrier Penetrations
Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: May, 2009
Information sheet about air sealing.

17. Thermal Enclosure System Rater Checklist Guidebook
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: October, 2011
Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
The following authors and organizations contributed to the content in this Guide.

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