Air Sealing Doors Adjacent to Unconditioned Space

Scope

Air seal doors adjacent to unconditioned space (e.g., outdoors, garages, vented attics, unconditioned basements, cellars, crawlspaces) to minimize air leakage and water intrusion. Weather stripping and sealants (e.g., gaskets, caulk, fire-retardant caulk, etc.) should be compatible with all adjoining surfaces and meet the fire and air barrier specifications according to code.

- Install a continuous gasket, such as weather stripping, around the interior perimeter of the door frame.
- Select an automatic closing door that is metal or fiberglass with an insulated foam-core and an ENERGY STAR rating if possible.
- Air seal the rough opening around the door with foam backer rod, non-expanding spray foam, and/or caulk.
- Flash around the exterior of the door frame with adhesive or liquid-applied waterproof flashing.
- Install a tight-fitting door sweep along the bottom of the door.

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.
Description

Exterior doorways are essentially large holes in the exterior shell of the home connecting the indoors to the outdoors or to other unconditioned spaces like garages, attics, and porches. Doors adjacent to unconditioned spaces should be treated the same way as exterior doors and are required to meet the same code requirements as exterior doors. With proper installation and air sealing, exterior doors do not have to represent a significant source of air leakage and heat loss. Exterior doors are usually sold as a kit with the frame attached. Insulated foam-core, metal or fiberglass ENERGY STAR doors are available and should be selected if possible. When the exterior door is installed in a new house, the rough opening (the space left for the door) is typically 1.5 to 2 inches larger than the door frame to give the installer room to install, plumb, and square the door. Once the door is set in place, some installers will stuff batt insulation into any gaps remaining in the rough opening around the frame. This fiber insulation may provide some insulation value but will not stop air flow. The rough opening should be filled with non-expanding foam or backer rod (a rod-shaped closed-cell foam product) and caulk. On the exterior, the door should be flashed with a fluid-applied or self-adhesive waterproof flashing that is properly integrated with the wall drainage plane and vapor barrier materials before siding is installed. The door frame should be weather stripped and a tight-fitting door sweep should be installed along the bottom of the door.

Air and water leaks around doors during high wind events can contribute to building failures; see the Climate tab for more information.

Air sealing could be done by the framer, the insulation contractor, or the contractor who installs the door. This task should be included in the contract for the appropriate trade depending on the workflow at the specific job site.

How to Air Seal the Exterior Doors

1. Select doors that are self-closing and fire-rated; consider ENERGY STAR-labeled metal- or fiberglass-clad insulated foam core doors.
2. Install the door per the manufacturer’s instructions. Install an automatic door closer. Fill the rough opening around the door with non-expanding foam or press backer rod into the wider gaps and seal the seams with caulk. Flash the door frame with adhesive waterproof flashing that is properly integrated with the wall sheathing and house wrap.
3. Install appropriate weather stripping to the door frame and threshold. See the table below for types. To determine how much weatherstripping you will need, add the perimeters of all the doors to be weatherstripped, then add 5% to 10% to accommodate any waste. Weatherstripping should be applied to clean, dry surfaces in temperatures above 20°F (-7°C). Make sure the weatherstripping meets tightly at the corners. Use a thickness that causes the weatherstripping to press tightly between the door and the door jamb when the door closes, without making it difficult to shut.
Figure 1 - Air seal door and window rough openings with backer rod, caulk, or nonexpanding foam. (Image courtesy of PNNL)

Figure 2 - Install an ENERGY STAR-labeled door with an automatic closer. Weather strip the door frame. (Image courtesy of PNNL)
Types of Weatherstripping *(DOE 2012)*:

<table>
<thead>
<tr>
<th>Weatherstripping</th>
<th>Best Uses</th>
<th>Cost</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tension seal:</strong> Self-stick plastic (vinyl) folded along length in a V-shape or a springy bronze strip (also copper, aluminum, and stainless steel) shaped to bridge a gap. The shape of the material creates a seal by pressing against the sides of a crack to block drafts.</td>
<td>Inside the track of a double-hung or sliding window, top and sides of door.</td>
<td>Varies</td>
<td>Durable, invisible when in place, very effective. Vinyl is fairly easy to install. Look of bronze works well for older homes.</td>
<td>Surfaces must be flat and smooth for vinyl. Can be difficult to install, as corners must be snug. Bronze must be nailed in place (every three inches or so) so as not to bend or wrinkle. Can increase resistance in opening/closing doors or windows. Self-adhesive vinyl available. Some manufacturers include extra strip for door striker plate.</td>
</tr>
<tr>
<td><strong>Felt:</strong> Plain or reinforced with a flexible metal strip; sold in rolls. Must be stapled, glued, or tacked into place. Seals best if staples are parallel to length of the strip.</td>
<td>Around a door or window (reinforced felt); fitted into a door jamb so the door presses against it.</td>
<td>Low</td>
<td>Easy to install, inexpensive.</td>
<td>Low durability; least effective at preventing airflow. Do not use where exposed to moisture or where there is friction or abrasion. All-wool felt is more durable and more expensive. Very visible.</td>
</tr>
<tr>
<td><strong>Reinforced foam:</strong> Closed-cell foam attached to wood or metal strips.</td>
<td>Door or window stops; bottom or top of window sash; bottom of door.</td>
<td>Low</td>
<td>Effective sealer, scored well in wind tests, rigid.</td>
<td>Can be difficult to install; must be sawed, nailed, and painted. Very visible. Manufacturing process produces greenhouse gas emissions.</td>
</tr>
<tr>
<td><strong>Tape:</strong> Nonporous, closed-cell foam, open-cell foam, or EDPM (ethylene propylene diene monomer) rubber.</td>
<td>Top and bottom of window sash; door frames; attic hatches and inoperable windows. Good for blocking corners and irregular cracks.</td>
<td>Low</td>
<td>Extremely easy to install, works well when compressed, inexpensive. Can be reinforced with staples.</td>
<td>Durability varies with material used, but not especially high for all; use where little wear is expected; visible.</td>
</tr>
<tr>
<td><strong>Rolled or reinforced vinyl:</strong> Pliable or rigid strip gasket (attached to wood or metal strips.)</td>
<td>Door or window stops; top or bottom of window sash; bottom of a door (rigid strip only).</td>
<td>Low-Med.</td>
<td>Easy installation, low to moderate cost. Self-adhesive on pliable vinyl may not adhere to metal; some types of rigid strip gaskets provide slot holes to adjust height, increasing durability. Comes in varying colors to help with visibility.</td>
<td>Visible.</td>
</tr>
<tr>
<td><strong>Door sweep:</strong> Aluminum or stainless steel with brush of plastic, vinyl, sponge, or felt.</td>
<td>Bottom of interior side of in-swinging door; bottom of exterior side of exterior-swinging door.</td>
<td>Med-High.</td>
<td>Relatively easy to install; many types are adjustable for uneven threshold. Automatically retracting sweeps also available, which reduce drag on carpet and increase durability.</td>
<td>Visible. Can drag on carpet. Automatic sweeps are more expensive and can require a small pause once door is unlatched before retracting.</td>
</tr>
<tr>
<td><strong>Magnetic:</strong> Works similarly to refrigerator gaskets.</td>
<td>Top and sides of doors, double-hung and sliding window channels.</td>
<td>High</td>
<td>Very effective air sealer.</td>
<td></td>
</tr>
<tr>
<td><strong>Tubular rubber and vinyl:</strong> Vinyl or sponge rubber tubes with a flange along length to staple or tack into place. Door or window presses against them to form a seal.</td>
<td>Around a door.</td>
<td>Mod-High.</td>
<td>Effective air barrier.</td>
<td>Self-stick versions challenging to install.</td>
</tr>
<tr>
<td>Weatherstripping</td>
<td>Best Uses</td>
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<td>------------------</td>
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</tr>
<tr>
<td><strong>Reinforced silicone:</strong></td>
<td>Tubular gasket attached to a metal strip that resembles reinforced tubular vinyl</td>
<td>On a doorjamb or a window stop.</td>
<td>Mod-high</td>
<td>Seals well.</td>
</tr>
<tr>
<td><strong>Door shoe:</strong></td>
<td>Aluminum face attachment with vinyl C-shaped insert to protect under the door.</td>
<td>To seal space beneath door.</td>
<td>Mod-high</td>
<td>Sheds rain on the exterior, durable. Can be used with uneven opening. Some door shoes have replaceable vinyl inserts.</td>
</tr>
<tr>
<td><strong>Bulb threshold:</strong></td>
<td>Vinyl and aluminum</td>
<td>Door thresholds.</td>
<td>Mod-high</td>
<td>Combination threshold and weatherstrip; available in different heights.</td>
</tr>
<tr>
<td><strong>&quot;Frost-brake&quot; threshold:</strong></td>
<td>Aluminum or other metal on exterior, wood on interior, with door-bottom seam and vinyl threshold replacement.</td>
<td>To seal beneath a door.</td>
<td>Mod-high</td>
<td>The use of different materials means less cold transfer. Effective.</td>
</tr>
<tr>
<td><strong>Fin seal:</strong></td>
<td>Pile weatherstrip with plastic Mylar fin centered in pile.</td>
<td>For aluminum sliding windows and sliding glass doors.</td>
<td>Mod-high</td>
<td>Very durable.</td>
</tr>
<tr>
<td><strong>Interlocking metal channels:</strong></td>
<td>Enables sash to engage one another when closed</td>
<td>Around door perimeters.</td>
<td>High</td>
<td>Exceptional weather seal.</td>
</tr>
</tbody>
</table>
Ensuring Success

Visually inspect exterior doors to see that weather stripping has been installed and that doors fit snugly with no air movement around perimeter or along trim when the door is closed. Verify that doors open freely with no drag on the threshold. Visually inspect that rough openings around door frames are air sealed before the drywall or door trim is installed. Check for air movement around the closed door and door trim with a smoke pencil or hand. Leaks will be easier to detect during a blower door test.
Climate

In high wind and hurricane prone areas, here is a summary of steps that can be taken to improve the storm resistance of exterior doors, based on the detailed information provided below and in the cited documents by FEMA and others:

- All exterior doors on homes in hurricane areas should be pressure and impact rated or protected by a system that is pressure and impact rated, according to the Insurance Institute for Business & Home Safety (IBHS 2019).
- Doors should be properly flashed, weather stripped, air sealed, and set in pan flashings designed to resist the entry of wind and wind-driven rain.
- For increased disaster resistance in coastal and high wind areas, install exterior doors to swing outward rather than inward. Weather stripping should be installed on the interior side of the door to minimize decay.
- Consider designing the home’s entry with a vestibule or double-doored entry. Construct the entry with durable water-resistant flooring.
- Install water-resistant flooring at all entryways.
- Doors, door framing, and door hardware should be made of water-resistant, corrosion-resistant materials.
- Exterior doors should meet U-factor requirements for the home’s climate zone, as required by local building codes. Please see the Compliance Tab for more information.
- See FEMA P-499 “Technical Fact Sheet No. 6.1: Window and Door Installation” for best-practice approaches that can be taken to reduce water infiltration. Pan flashing, weather stripping, and threshold seals are discussed. The Solution Center guide “Fully Flashed Window and Door Openings” and the Tech Note: Window and Door Flashing: Code Requirements and Best Practices” by Home Innovation Research Labs provide additional detailed instructions for installing window and door flashing.

In all areas where buildings are constructed, windows and doors tend to be more vulnerable to damage than other portions of a building’s envelope. In coastal areas where high winds, windborne debris, and wind-driven rain are common and often intense their vulnerabilities are more pronounced (FEMA P-762 2009). Air leaks around doors can allow in wind during high-wind events, contributing to an increase or decrease in internal pressures that can contribute to building failures (FEMA P-762 2009). Flashing is required by the IRC Section R703.8 to prevent moisture from entering the wall system.

Water leakage around windows and doors is also quite common but because the effects of water leakage are often subtle, the full effects of water leakage are often not readily apparent. Water-resistant siding materials like vinyl and veneer can hide moisture damage in the sheathing caused by rainwater entry for years. Leakage or water entry, due to inadequate or improperly installed flashing, weather stripping, or weather resistant barriers, can allow water to enter a building’s interior even when the structure of the window or door remains intact. Water intrusion can cause rot and fastener corrosion that can weaken the window or door frame or the wall framing itself. Leakage can also cause damage to interior finishes and facilitate mold growth (FEMA P-762 2009).

Windows and doors can fail if they are not strong enough to resist wind pressures from a high-wind event or if forces exerted on the doors or windows exceed the strength of their anchorage. When strength is inadequate, the window or door’s glazing or frames fail; when anchorage is inadequate, the entire door or window unit can be torn from its mounting. As wind speeds increase due to storm strength in Category 2 or weak Category 3 levels, failures of these elements become more frequent. Wind pressure increases resulting from the failure of windows and doors can significantly increase (in some cases doubling) the wind forces working to blow the roof off or blow out exterior walls.

The FEMA P-762 Local Officials Guide to Coastal Construction provides the following guidance on window and door leakage (excerpted). Hurricanes and coastal storms can pose significant problems from water-infiltration due to wind-driven rain. Leakage can occur between the door or window and their frames and between the door/window frames and the walls onto which they are mounted. Coastal storms such as tropical storms and hurricanes generate winds that may approach or exceed the wind speeds observed during design wind events. As such, these winds generate high-wind pressures on the outsides of the buildings, exploiting any vulnerability around doors and windows and allowing water to enter buildings.

Further, leakage rates typically increase with greater wind speeds. While the amount of water entry that can result from leakage around windows and doors will typically be much less than the amount of water entry that can result from a breach in the building envelope, actions can and should be taken to help reduce leakage around doors and windows. These actions are often code-plus or best-practices approaches.

Code Requirements for Window and Door Leakage - Proper door and window construction is critical to reducing water infiltration. Section R613.4 of the IRC and Section 1714.5.1 of the IBC require windows and sliding doors to be certified per AAMA/WDMA/CSA 101/1.S.2/A440, Standard/Specification for Windows, Doors, and Unit Skylights. Hinge doors must be certified per ASTM E330, Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference. Both standards specify wind-pressure and water-leakage criteria that must be met in order to comply with code requirements. In general, water-leakage tests are conducted at much lower differential pressures (typically 20 percent) than the pressures used to determine the strength of the glazing, window, or door assembly. This implies that some water entry through doors and windows should be anticipated during an event that produces design wind pressures and wind-driven rain.

Reducing Window and Door Leakage - FEMA 499, Technical Fact Sheet No. 6.1: Window and Door Installation, Window and Door Installation, provides some best-practices approaches that can be taken to reduce water infiltration. Pan flashing (i.e.,
flashing under window sills), weather stripping, and threshold seals are discussed. Other actions can be taken to reduce the potential for water entry. These include:

**Reducing Window and Door Leakage** - FEMA 499, Technical Fact Sheet No. 6.1: Window and Door Installation, Window and Door Installation, provides some best-practices approaches that can be taken to reduce water infiltration. Pan flashing (i.e., flashing under window sills), weather stripping, and threshold seals are discussed. Other actions can be taken to reduce the potential for water entry. These include:

- **Vestibules.** Designing a vestibule, or double-doored entry, to protect a door entry is one method of managing water infiltration problems. Through this approach, both the inner and outer doors can be equipped with weather stripping, and the vestibule itself can be designed to tolerate water. For example, water-resistant finishes (e.g., concrete or tile) can be specified, and the floor can be equipped with a drain. As a result, a secondary layer of protection is provided for the primary entrance (via the vestibule and vestibule door).

- **Door swing.** Out-swinging doors offer an advantage compared to in-swinging door assemblies. With out-swinging door assemblies, the weather stripping is located on the interior side of the door, where it is less susceptible to degradation than the exposed weather stripping on in-swinging door assemblies. Also, some interlocking weather-stripping products are available for out-swinging door assemblies that provide better performance than those used on in-swinging door assemblies.

- **Finish selection.** One design approach to deal with leakage is to avoid running carpet (or other finishes that can be damaged by water) entirely to the edge of walls that contain a large amount of glazing. Instead, a strip of water-resistant material (such as tile) could be specified along the wall so if light to moderate leakage occurs, the potential for damage to interior finishes and contents is greatly reduced.

**Window and Door Assembly Capacities** - Window and door assemblies must be strong enough to withstand wind pressures acting on them and be fastened securely enough to transfer those wind pressures to the adjacent wall. Pressure failures of doors or windows can allow glazing to fracture or glazing frames or supports to fail. Anchorage failures can allow entire door or window units to be ripped from their walls. Either type of failure results in the failure of the building envelope and allows wind and water into the building.

**Code Requirements for Strength and Anchorage** - Both the International Residential Code (IRC) and the International Building Code (IBC) contain specific requirements for the wind resistance of windows and doors. Section R613.3 of the IRC requires that exterior windows and doors be designed to resist the wind pressures specified in Table R301.2(2). Table R301.2(2) lists positive and negative wind pressures for C&C for various locations within the building. Areas near roof and wall edges and areas near corners, where turbulence creates localized high wind pressures, must be designed for higher loads. Table R301.2(2) is based upon Exposure B conditions for buildings with a mean roof height of 30 feet or less. Table R301.2(2) pressures must be multiplied by factors listed in Table R301.2(3) for different mean roof heights and exposures.

The IBC requirements are similar but are less prescriptive and more performance-based. While the IRC has tabulated wind pressures, Chapter 16 of the IBC specifies acceptable methods of calculating wind loads and (in Section 1603.1.4) requires that construction documents list wind pressures for C&C.

IBC Section 1405.12, Exterior Windows and Doors, requires windows and doors to be tested in accordance with IBC Section 1714.5, which lists two methods of establishing wind resistance. Section 1714.5.1 allows doors and windows to be labeled per AAMA/WMDA/CSA 101/I.S.2/A440; Section 1714.5.2 allows doors and windows to be tested per ASTM E330. The latter option has additional requirements regarding glass supports and framing that are outlined in Section 2403 and pressure ratings for Section 1714.5.2 are outlined in Chapter 16, the structural design chapter of the IBC.

AAMA/WMDA/CSA 101/I.S.2/A440 lists design test pressures of 15, 25, 30, and 40 psf. Windows and doors used in areas where wind pressures are greater than 40 psf need to be tested per ASTM E330. For residential construction, local officials must ensure that products proposed are adequate to resist the C&C loads of Table R301.2(2). For engineered construction, the designer should specify wind pressures required for windows and doors and should base them on C&C loads from either Chapter 6 of ASCE 7-05 or Chapter 16 of the IBC.

Section R613.8.1 of the IRC requires that windows and glass doors be anchored in accordance with published manufacturer’s recommendations. The manufacturer’s installation instructions should match those used when the units were tested and certified. Substitute anchorage systems are allowed if they provide equal or greater anchoring performance as demonstrated by accepted engineering practice.

The IRC contains Figures R613.8(1) through R613.8(8) that provide minimum anchorage details. The details require windows and doors to be anchored in a fashion that adequately transfers loads from the windows and doors to the adjacent walls (the walls are called substrates in that code). When the space between the window or door frame and the wall’s rough opening is 1.5 inches or less, shims or bucks can be installed and fasteners can extend from the door or window frame to the wall. When the space is greater than 1.5 inches, the bucks need to be securely fastened to the wall and the door, or window frames need to be securely fastened to the bucks. This requirement limits the shear length of fasteners to 1.5 inches and reduces the potential for bending failures in the fasteners. The IRC requirements are similar but do not provide the prescriptive details contained in the IRC. IBC Section 1405.12.1 requires windows and doors to be installed in accordance with approved manufacturer’s instructions.

To minimize issues related to corrosion, the use of fiberglass or vinyl frames are recommended for buildings located within 3,000
feet of an ocean shoreline. The use of stainless steel frame anchors, fasteners, and hardware is also recommended within these areas. In areas where severe termite or insect infestation problems exist, wood frames should either be treated or should be constructed with wood that is naturally insect- and rot-resistant. Shims and bucks should be pressure-treated. Since some pressure treatment increases the moisture content of framing, the use of material that is kiln dried after treatment is suggested to control shrinkage.

In areas where insect infestation problems exist, metal door assemblies are recommended. If concrete, masonry, or metal wall construction is used to eliminate termite problems, wood used for blocking or bucks should be treated or naturally insect- and rot-resistant species of wood should be used (FEMA P-762 2009).
Training

Right and Wrong Images

Display Image: ES_TESRC_5.3.1_PG154_340b_102811_0.jpg
Right – This exterior door is installed to swing out and has storm protection shutters.
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.
4. Air Sealing (Unless otherwise noted below, “sealed” indicates the use of caulk, foam, or equivalent material).
4.9 Doors adjacent to unconditioned space (e.g., attics, garages, basements) or ambient conditions made substantially air-tight with weatherstripping or equivalent gasket.

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.

American Architectural Manufacturers Association (AAMA)/Window and Door Manufacturers Association (WDMA)/CSA 101/I.S.2/A440-08 North American Fenestration Standard/Specification for windows, doors, and sky lights (NAFS)

North American Fenestration Standard/Specification for Windows, Doors, and Skylights. Available from AAMA. This is a voluntary standard/specification that covers requirements for the following components for new construction and retrofits: single and dual windows, single and dual side-hinged door systems, sliding doors, tubular daylighting devices, and unit skylights.


2009 International Energy Conservation Code (IECC) and 2009 International Residential Code (IRC)

IECC Table 402.4.2/IRC Table N1102.4.2. Air Barrier and Insulation Inspection Component Criteria, Windows and doors: Seal space between window/door jambs and framing.

2009 IECC 402.4.1/IRC N1102.4.1 Air leakage, Building Thermal Envelope - The building thermal envelope should be constructed to limit air leakage. Methods used to seal between dissimilar materials should allow for differential expansion and contraction. Sources of infiltration (see listing below) should be caulked, gasketed, weather-stripped, or otherwise sealed with an air-barrier material, suitable film, or solid material: All joints, seams, and penetrations, Utility penetrations, Rim joist junction, Other sources of infiltration.

2012, 2015, and 2018 IECC / 2012, 2015, and 2018 IRC

IECC Table R402.4.1.1/IRC Table N1102.4.1.1. Air Barrier and Insulation Installation, Windows, skylights and doors: Seal space between window/door jambs and framing and skylights and framing. Table R402.4.1.1 Air Barrier and Insulation Installation, Narrow cavities: Batts in narrow cavities are cut to fit; or narrow cavities are filled with insulation that readily fills the available cavity space. Continuous air barrier. Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation of the exterior wall(s). Breaks or joints in the air barrier should be sealed. Air-permeable insulation should not be used as a sealing material.

2015 IECC/IRC, R402.4./N1102.4 Air Leakage. The building thermal envelope should be constructed to limit air leakage.

R402.4.1/N1102.4.1 Building Thermal Envelope. Methods used to seal between dissimilar materials should allow for differential expansion and contraction.

R402.4.1.1/N1102.4.1.1 Installation. The components listed in the Air Barrier and Insulation Installation Table should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction.


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.)


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

See the Climate tab for more codes information related to flashing doors and windows for disaster resistance.
More Info.

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.

Case Studies

1. **New Whole-House Solutions Case Study: Nelson Construction: Hamilton Way, Farmington, CT**
   - **(662KB)**
   - **Author(s):** PNNL
   - **Organization(s):** PNNL
   - **Publication Date:** April, 2012
   - Case study about design and testing 10 high-performance homes in Farmington, Connecticut.

References and Resources*

1. **Building America Best Practices Series, Volume 10: Retrofit Techniques and Technologies: Air Sealing**
   - **Author(s):** Baechler, Gilbride, Hefty, Cole, Williamson, Love
   - **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   - **Publication Date:** April, 2010
   - Report identifying the steps to take, with the help of a qualified home performance contractor, to seal unwanted air leaks while ensuring healthy levels of ventilation and avoiding sources of indoor air pollution.

   - **Author(s):** Federal Emergency Management Agency
   - **Organization(s):** FEMA
   - **Publication Date:** December, 2010
   - Report containing 37 fact sheets that provide technical guidance and recommendations concerning the construction of coastal residential buildings.

3. **FEMA P-762: Local Officials Guide for Coastal Construction**
   - **Author(s):** Federal Emergency Management Agency
   - **Organization(s):** FEMA
   - **Publication Date:** February, 2009
   - A guide aiming to assist local officials and community decision makers in coastal areas in adopting and implementing sound mitigation measures to lower building natural disaster vulnerability.

4. **Fortified Home Hurricane Standard**
   - **Author(s):** Insurance Institute for Business & Home Safety
   - **Organization(s):** IBHS
   - **Publication Date:** May, 2019
   - Guide describing the requirements by FORTIFIED Home™ for improving the home’s resistance in severe thunderstorms, straight-line wind events, and high winds at the outer edges of tornadoes.

5. **Keep Safe: A Guide for Resilient Housing Design in Island Communities**
   - **Author(s):** Enterprise Community Partners
   - **Organization(s):** Enterprise Community Partners
   - **Publication Date:** January, 2019
   - A guide providing tools to island and hurricane-prone communities on redevelopment and rehabilitation of homes to prepare for future natural disasters.

   - **Author(s):** American Architectural Manufacturers Association
   - **Organization(s):** American Architectural Manufacturers Association
   - **Publication Date:** May, 2008
   - Standard covering requirements for single and dual windows, single and dual side-hinged door systems, sliding doors, tubular daylighting devices, and unit skylights for new construction and replacement applications.

7.
RETROFIT Improvements: Improve Window & Door Flashing/Sealing
Author(s): Home Innovation Research Labs
Organization(s): HIRL
Publication Date: February, 2012
Fact sheet describing methods for flashing and air sealing windows and doors.

Author(s): Home Innovation Research Labs
Organization(s): Home Innovation Research Labs
Publication Date: September, 2015
This TechNote provides an overview of building code requirements and best practices for flashing at window and door frames.

9. 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.

10. Weatherstripping
Author(s): Department of Energy
Organization(s): DOE
Publication Date: May, 2012
Information sheet explaining how weatherstripping can be an easy and cost-effective way to save money on energy costs and improve comfort by reducing drafts.

*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
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