CONSTRUCTION GUIDE

# NEXT GENERATION HIGH PERFORMANCE WALLS

## CLIMATE ZONES 3-5
## PART 1: 2X6 WALLS

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June 2017

**CONSTRUCTION GUIDE**

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## Part 1: 2x6 walls

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# TABLE OF CONTENTS

# CONSTRUCTION GUIDE

## NEXT GENERATION HIGH PERFORMANCE WALLS
## CLIMATE ZONES 3-5
## PART 1: 2X6 WALLS

## TIME-PROVEN, PRACTICAL, AND COST-EFFECTIVE STRATEGIES TO CONSTRUCTING DURABLE, ENERGY EFFICIENT WALLS

The 2x6 advanced framing technology enables a straightforward transition from conventional 2x4 wall construction to a more energy efficient wall system requiring only a minimal change from tried-and-true framing practices. Walls with 2x6 studs spaced either 16 or 24 in. on center have been used with various approaches to insulation, air sealing, and moisture control as far north as Alaska and have a long history of successful performance. In addition to a deeper cavity that provides space for more insulation, 2x6 studs have significantly higher compression and bending capacity that allow for increased stud spacing and reduced number of jack and king studs at openings. The use of fewer studs per a unit of length of wall leads to reduced framing factor (leaving more room for insulation), material cost-savings, resource efficiency, and labor savings during framing as well as installation of utilities. In addition to familiar advanced framing practices, new techniques are included such as the rim header and continuous drywall at interior wall intersections, which further optimize framing and increase energy efficiency.

### SCOPE

Part I of the Guide addresses walls constructed with 2x6 wood frame studs, wood structural panel (WSP) sheathing as exterior sheathing, gypsum board as interior sheathing, and a cladding system installed over WSP sheathing in low-rise residential buildings up to three stories in height. The Guide is aligned with the provisions of the 2012/2015 International Residential Codes (IRC) as indicated throughout the document within specific sections. The primary application for this wall system is in IRC Climate Zones 3-5.Walls with exterior board insulation are addressed in Part II of the Guide.

Part I addresses all aspects of the wall construction as outlined in Table 1 and in Figure 1.

### LIMITATIONS AND CONSIDERATIONS

Thermal bridging through the studs and plates limits the wall's system R-value. In typical framed walls, the exterior sheathing is at or near the outdoor temperature that leads to seasonal cyclic moisture content fluctuations in the sheathing. Moisture movement both from the exterior and the interior must be managed appropriately for the climate and the wall construction.

**Table 1. Summary of Topics**

| WALL FEATURE | DESCRIPTION | PAGE |
|---|---|---|
| **Number of Stories** | Prescriptive 2x6 framing spacing is defined by the number of stories and the use of the attic space. | 3 |
| **Story-to-Story Stud Alignment** | Walls framed at 24 in. on center require floor or roof framing at more than 16 in. on center to be within 5 in. of the stud unless a 2x6 double top plate is used. | 4 |
| **Corners** | Various framing options reducing thermal bridging are included in the Guide for stick-framed or panelized construction. | 5 |
| **Interior Wall Intersections** | Various options are included to reduce thermal bridging and improve air tightness, with one suggested preferred option. | 7 |
| **Framing at Openings** | Optimized designs for headers and supporting jack and king studs are addressed. | 8 |
| **Insulating Rim Joist** | Because insulation at the rim area is often handled differently from the cavity insulation, different approaches to rim insulation integrating various performance goals are provided. | 19 |
| **Modular Layout of Openings** | Modular layouts are used to optimize material use and reduce waste. Locating window and door openings to align with the stud spacing can help reduce the number of studs in the wall. | 22 |
| **Exterior Wall Sheathing** | Prescriptive requirements for wall structural sheathing for stud spacing at 16 and 24 in. on center. | 23 |
| **Interior Gypsum Sheathing** | Prescriptive requirements for interior gypsum sheathing are included for stud spacing at 16 and 24 in. on center. | 24 |
| **Cavity Insulation** | Various types and installation methods for cavity insulation are outlined, including a comparison of features. | 25 |
| **Air Sealing** | Approaches to air sealing of the frame wall system are included, including both exterior and interior details. | 26 |
| **Water Vapor Management** | Approaches and material applications are enumerated to ensure durability of the wall system based on various exterior cladding solutions. | 31 |
| **Water Resistive Barrier** | Details on the application of a WRB incorporating options for different materials are provided. | 36 |
| **Claddings** | With new requirements for attachment of claddings to framing and structural sheathing introduced in recent building codes, the Guide outlines these requirements and provide details on different cladding materials. | 38 |
| **Window and Door Installation and Flashing** | Because window and door installation and flashing details vary only minimally from the standard 2x4 construction, this subject is not addressed in detail in this guide. | 44 |
| **Energy Efficient Trusses** | Though not specifically part of the wall design, the presented wall-roof interface solution integrates the wall sheathing with the high-heel truss for improved energy efficiency and durability. | 47 |

# NUMBER OF STORIES

2x6 framing at 24 in. on center is permitted for one- and two-story houses with or without a habitable attic. For three-story construction, the maximum 2x6 stud spacing for the bottom story is 16 in. on center (upper stories are allowed to be at 24 in. on center). Table 2 diagrams the allowances for the maximum stud spacing based on the number of supported stories for load-bearing walls. In nonbearing exterior walls, 2x6 studs spaced at 24 in. on center can be up to 20 feet in height (Table 3).

The stud spacing requirements are based on the provisions of the International Residential Code. In addition to the number of stories, factors that may influence stud layout include fastening schedules for cladding and sheathing where penetration into the framing is required (see page 39).

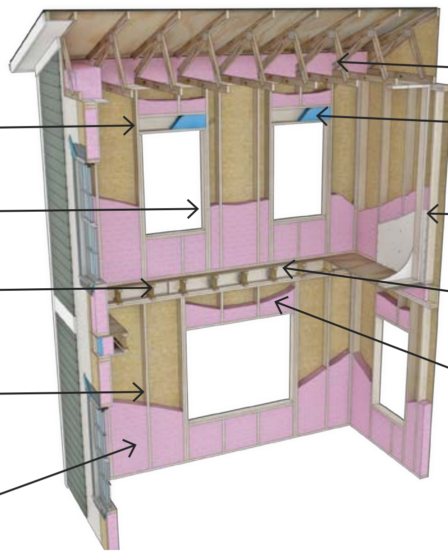



**Figure 1. Advanced Framing Features**

## WHY TRANSITION TO 24 IN. ON CENTER FRAMING?

Framers and builders may be reluctant to switch to 24 in. on center framing due in large part to the “hassle” factor. The case to switch has been made as a cost-savings (primarily lumber) opportunity, but some builders have acknowledged other related benefits:

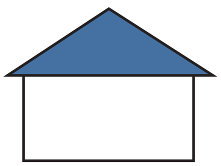
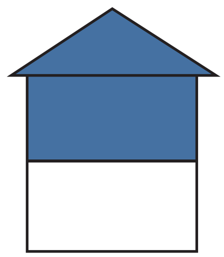
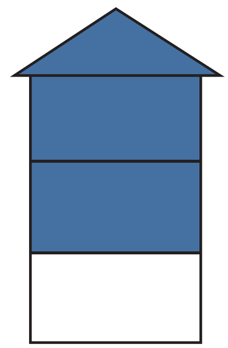
- Electricians and plumbers will need to drill fewer holes when running cable or tubing;
- Insulators have fewer cavities to install which means less stopping to measure and cut;
- Energy designers can take credit for more insulation and a lower framing factor;
- Air sealing cavities requires less material and time; and,
- Gypsum installation is faster with less hardware required.

Builders realize that not all of these savings may translate directly into reduced costs but do recognize that benefits can accrue in maintaining construction schedules or minimizing cost increases when they do occur.

### STORY-TO-STORY STUD ALIGNMENT

For 2x6 walls with a double top plate, individual studs between stories need not conform to in-line framing regardless of the stud spacing on any of the stories for buildings up to 3 stories in height. Therefore, studs can be spaced at 24 in. or 16 in. on center on any of the stories without triggering the need for story-to-story alignment. Compared to 2x4 studs at 24 in. on center that require stud alignment within 5 in. for joists, trusses, or rafters spaced more than 16 in. on center (see IRC Section 602.3.3), this feature of 2x6 framing simplifies framing layouts and installation. Columns that support concentrated loads always have to align (regardless of stud spacing), and typically require blocking within floor framing per standard construction practice.

**Table 2. Maximum stud spacing for bearing walls of lowest level with 2x6 framing and stud height of 10 feet or less [A]. (Note: the 2018 IRC will allow a 12 foot stud height in most cases.)**

| 24 in. | 24 in. | 16 in. |
|---|---|---|
|  |  |  |
| Supporting Roof/ Ceiling w or w/o habitable attic | Supporting One Floor and Roof/ Ceiling w or w/o habitable attic | Supporting Two Floors and Roof/ Ceiling w or w/o habitable attic |

[A] Shaded areas indicate habitable space being supported by the lowest framed wall section (unshaded)

**Table 3. 2x6 Stud Spacing and Height in Nonbearing Walls**

| Max Stud Spacing | Max Stud Height |
|---|---|
| 24 in. | 20 ft. |

# CORNERS

Conventional 2x4-wall corners with multiple-studs forming a solid wood block lead to significant thermal bridging at those locations and often result in poor quality of adjacent insulation installation. Many of these multiple framing members are typically not needed from the structural standpoint unless supporting a concentrated load (e.g., header, beam). **The primary corner framing functionality is to enable connecting the intersecting walls to each other, provide a nailing surface for cladding and trim and drywall, and for attaching holddown hardware (if applicable).** The intersecting walls can be connected to each other at corners by one of two methods: (1) nailing two adjacent studs to each other or (2) nailing continuous WSP sheathing from both walls to a common stud. The continuity of the top plate is provided by overlapping double top plates or by using a metal plate (with double or single top plate).

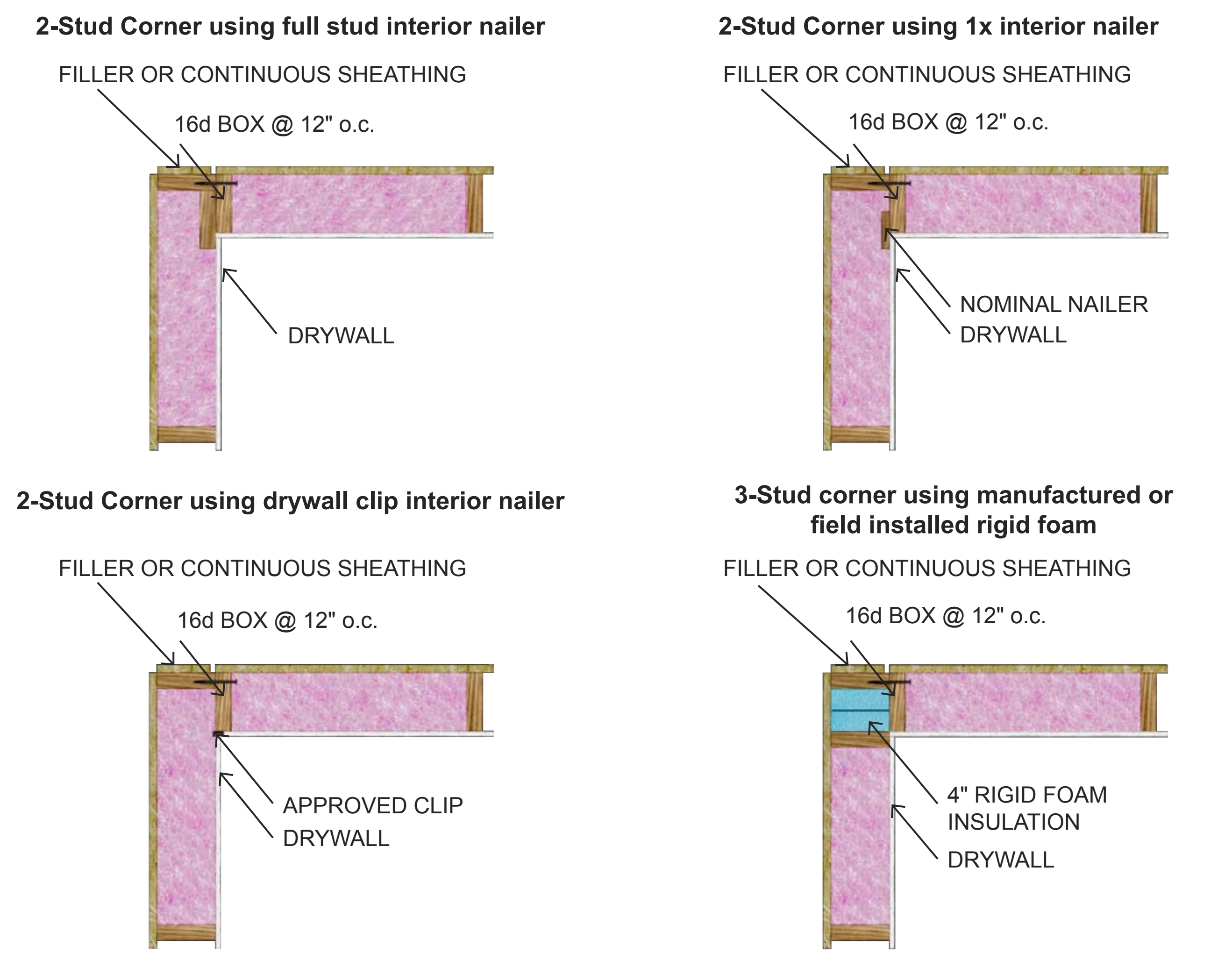
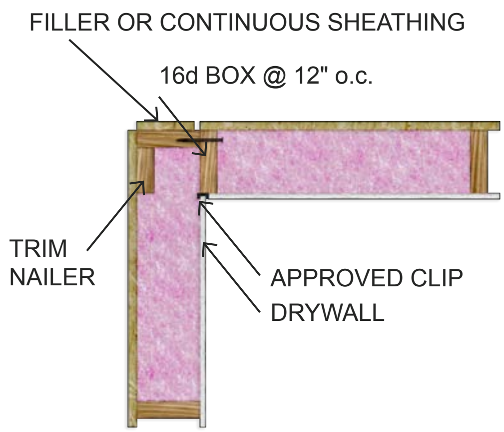



**Figure 2. Corner Framing Details for Cladding Systems That Do Not Require Additional Framing for Trim**

Several energy efficient corner framing options are shown in Figure 2, Figure 3, and Figure 4. The added cavity depth in a 2x6 wall allows for installation of nailers for exterior claddings and interior sheathing with only a minimal effect on the performance of insulation at those locations.

**2-Stud Corner Using Drywall Clip and Exterior Nailer**




**3-Stud Corner Using Exterior Nailer and Field Installed Rigid Foam**

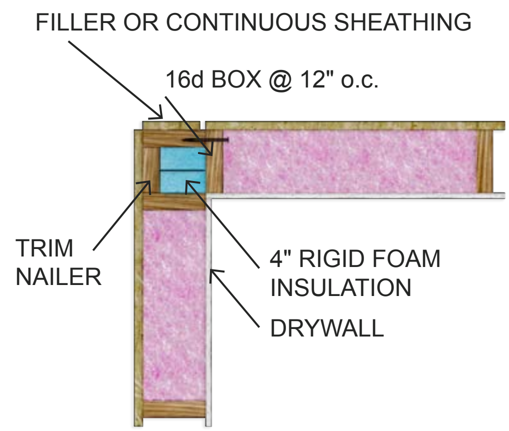
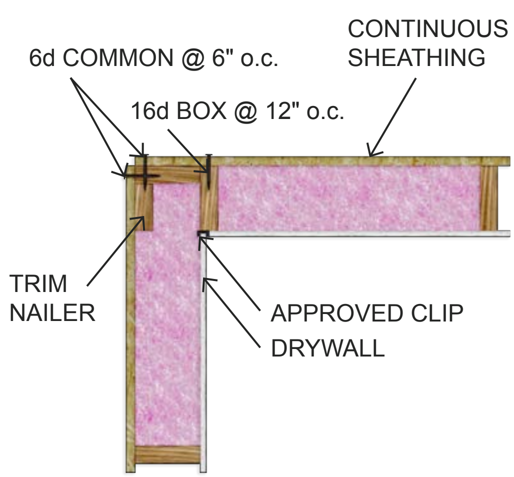



**Figure 3. Corner Framing Details for Cladding Systems That Require Added Framing for Trim**



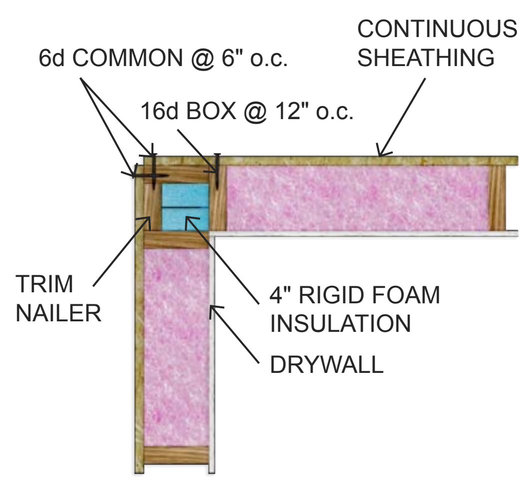




**Figure 4. Continuous Sheathing Option Examples**

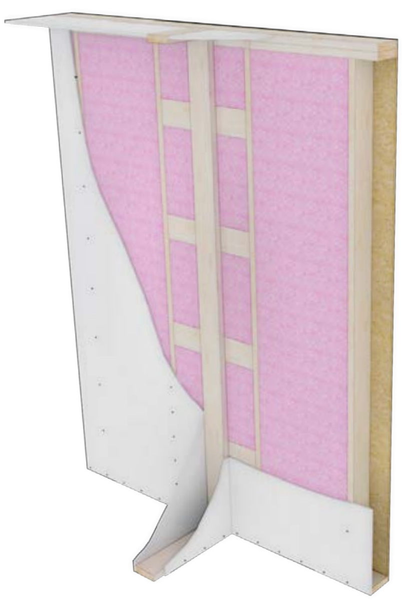
# INTERIOR WALL INTERSECTIONS

Intersections of interior and exterior walls can cause interruptions in the wall's thermal barrier and interior air barrier. Additional framing installed at intersecting walls only serves as nailers for drywall and is not structurally needed unless supporting a concentrated load from a header or a beam. Conventional framing options for intersecting walls lead to thermal bridging, reduce quality of insulation installation, and create air leakage paths for the interior air into the wall cavity and potentially into the floor or attic and to the outside. The framing options shown in Figure 5 minimize disruption to installation of insulation and enable better air sealing performance: (1) ladder blocking and (2) continuous drywall. Neither option introduces any additional studs in the exterior wall, maintaining the standard stud spacing at 16 or 24 in. on center.

For either option, the interior walls can be load-bearing walls or nonbearing partition walls. Neither wall type requires the end stud to be attached to the framing in the exterior walls. Therefore, gypsum on the exterior wall can be attached to blocking or installed in an uninterrupted manner (continuous drywall method). Interior wall top plates must always be attached to structural members at floors or roofs (as applicable) per standard framing practice to ensure wall's stability.

In load bearing interior walls, the double top plate of the interior wall must overlap with the double top plate of the exterior wall. Alternatively, a metal plate can be installed connecting the top plates to each other (for single or double top plate walls). Metal plates approved for this application are available from hardware manufacturers. There are no requirements for interior nonbearing walls to have the plates connected to the exterior wall.

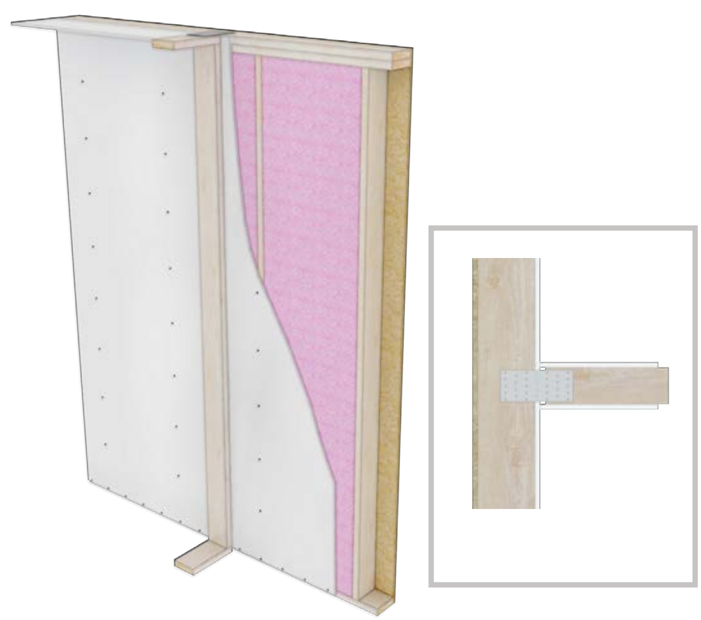
**LADDER BLOCKING**



Ladder blocking at 18" to 24" on center

Air leakage pathway from interior wall to exterior wall section – additional air sealing is recommended

**CONTINUOUS DRYWALL**



Offset interior wall by 1" such that the gypsum can slide in between, metal galvanized steel connecting plate at top plates

No interior wall air leakage pathway at the partition wall studs

**Figure 5. Advanced Framing Details for Intersecting Walls**

# FRAMING AT OPENINGS

Solid headers, jack studs, and king studs at openings contribute to thermal bridging and increased framing factor. Because 2x6 members have a greater bending capacity, fewer studs are required to carry the same load from supported headers. In addition, the deeper cavity in a 2x6 wall provides more space for insulation at headers. Therefore, 2x6 framing can always achieve a lower framing factor than a 2x4 framing in a wall with the same configuration of openings.

For header spans under specific loading conditions and for other structural requirements refer to the governing building code, approved manufacturers specifications, or design by a licensed professional. Example header spans or span ranges are provided below for each header type to help bound appropriate application for each technology.

## NOTE

In nonbearing walls, headers are not needed (Figure 6) and the framing layout at openings is controlled by compliance with the requirements for attachment of sheathings and claddings. A single king stud can be used without jack studs at the edges of the opening. Where opening in a nonbearing wall exceeds 8 feet, the opening's top plate must be a double 2x member or be supported by structural sheathing (e.g., OSB sheathing).

For load-bearing walls, there are four types of advanced header options included in this Guide:

1. insulated single header;
2. box header;
3. insulated double headers;
4. rim header.

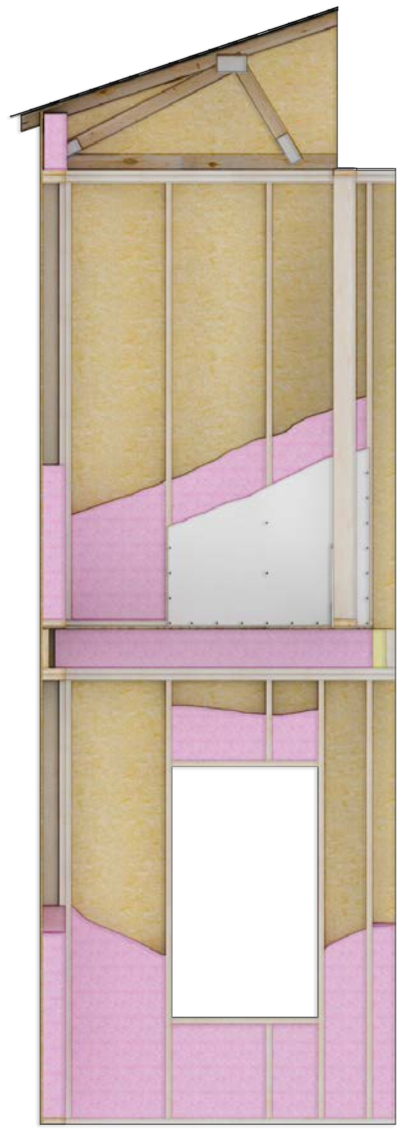


**Figure 6. Header Not Required in Non-Load Bearing Wall**

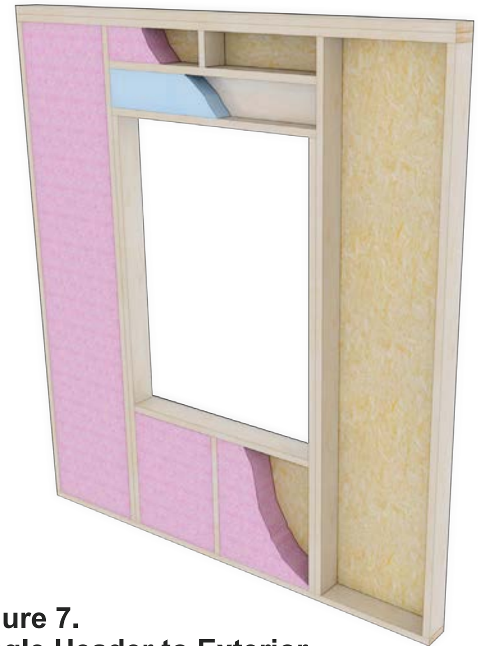


**Figure 7.**
**Single Header to Exterior, Rigid Insulation Board in Cavity**

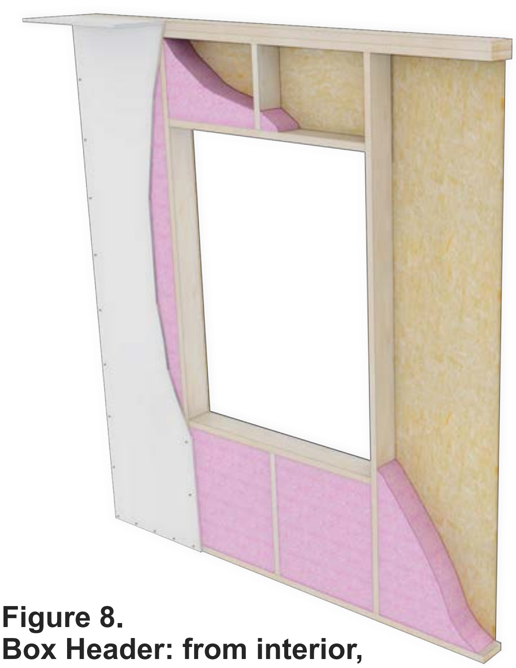
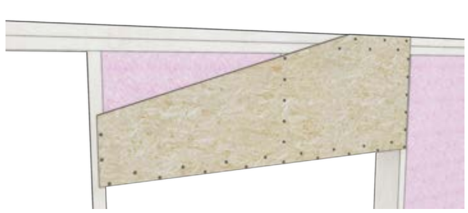


**Figure 8.**
**Box Header: from interior, above, and exterior, below**



## INSULATED SINGLE HEADER

A single "right-sized" header in a 2x6 wall allows for 4 in. of insulation (Figure 7) at the header for an R-value of 20 (XPS). The most appropriate application for single headers is in one-story buildings (or top story of multi-story buildings) for openings up to 6 feet wide for solid sawn lumber and for openings up to 7 feet wide for wood structural composite lumber. When used in two-story buildings with a center-bearing floor, the maximum opening size is reduced roughly by one foot, limiting this method to smaller openings. (See page 12 on jack studs and king studs for the number of studs adjacent to openings.)

## BOX HEADER

For openings in top floors and in single-story buildings, single-side WSP box headers provide another alternative for openings 3 to 5 feet wide. Single-side box headers are assembled with OSB or plywood nailed to framing, including cripples at stud spacing, at 3 in. on center (see Figure 8). The IRC provides prescriptive options for 9- and 15-in. deep headers (Refer to Table 4). The WSP must have the minimum thickness of 15/32 in. and be rated for exterior wall sheathing applications (Exposure 1) – a standard minimum rating for all WSPs. The WSP at the header must be oriented with the strong axis (typically the panel's longer edge) in the horizontal direction. Box headers can also be sheathed with WSP on both sides of the wall providing a greater spanning capacity; this option is less practical for residential applications because the interior WSP interferes with the gypsum wallboard installation.

**Table 4. Single-side Box Header in One-Story (or Top Story) Applications, Maximum Opening (ft)**

| Header depth (in.) | Clear Roof Span, ft | | | |
|---|---|---|---|---|
| | 26 | 28 | 30 | 32 |
| 9 | 4 | 3 | 3 | - |
| 15 | 5 | 4 | 3 | 3 |
| Maximum snow load of 50 psf. | | | | |

Figure 9. Insulated Double Headers

## INSULATED DOUBLE HEADERS

The additional depth of 2x6 walls allows for integrating 2.5 in. of rigid insulation with double headers that are site-built or delivered prefabricated (Figure 9). This option can be used with solid sawn or engineered lumber header framing. Double headers are sufficient to span most openings in a typical house. Depending on the type of rigid insulation and the thickness of header framing members, the total system R value of 13 to 19 can be achieved (compared to R5 for a wood-only header). Rigid foam insulation can be installed to the interior side of the header or between the framing members. An exterior foam installation is not recommended unless approved by a licensed professional. A single or double top plate must cap header if insulation is installed between the header framing members. The use of fiberglass batts or open cell spray foam is also an option for interior face application, but it results in reduced thermal performance.

## RIM HEADER

By relying on the floor rim joist for carrying the gravity load around the openings (Figures 10 and 11), rim header designs enable uninterrupted installation of insulation in walls above doors and windows. One of the key details of the rim header assembly is the metal joist hangers used to support floor joists at the rim. **In the rim header design, king studs perform double duty by resisting both gravity loads and out-of-plane wind loads, thereby reducing the total number of 2x6 studs at the opening. For many narrow openings (4 feet or less), a single 2x6 stud is sufficient on each side of the opening (compared to 2 studs—a jack and a king—for a conventional header stud layout).** Note that this benefit does not directly translate to 2x4 stud walls with rim headers because of the reduced capacity of 2x4 stud framing (relative to 2x6 studs).

Rim headers can be framed with solid-sawn lumber, engineered wood lumber or trusses. Use of solid sawn lumber joists with an engineered rim is not recommended due to the difference in shrinkage. As with conventional headers, single-ply or multi-ply rim headers are selected based on the magnitude of the supported load (i.e., number of stories, floor joist span, snow loads, etc.) Additional nailing of the rim members to each other in multi-ply applications may be required along the top and bottom edges to ensure the rim joist acts as a unit. Where face-mounted joist hangers are used, the face nails also connect the adjacent rim members to each other. **Each ply in a rim header must be continuous over the entire span of the opening below (i.e., no splice joints or butt joints) and must extend beyond the opening to ensure load transfer from the rim into the supporting king studs.** Rim headers are referenced in the 2015 IRC for solid sawn lumber. Engineered wood products compliant with proprietary evaluation reports are used as an alternative to solid sawn lumber applications.

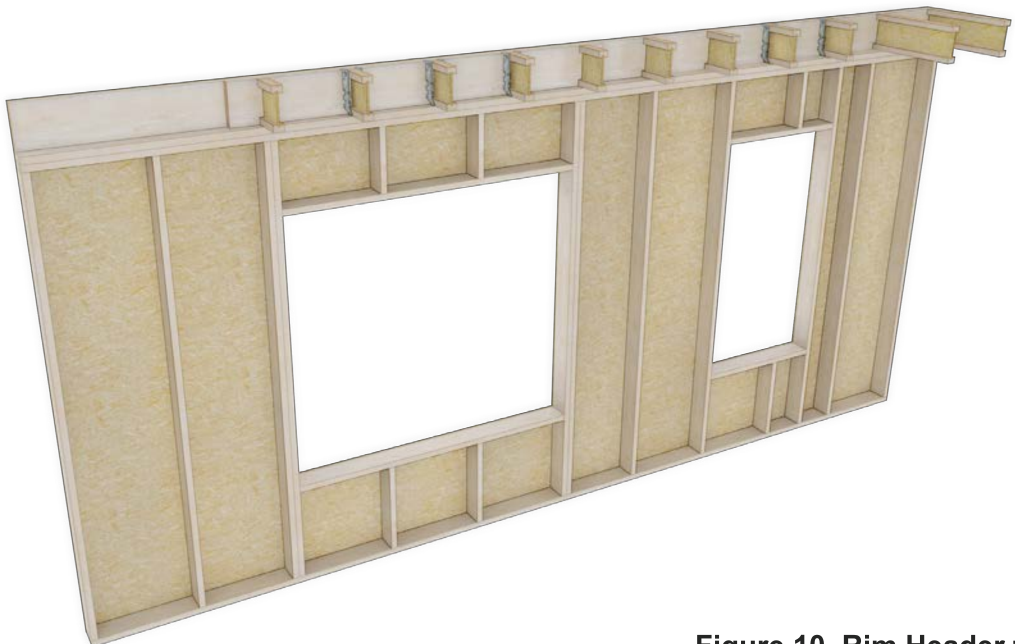


**Figure 10. Rim Header to Span Openings**

**Figure 11. Rim Header Top**

## RIM HEADER: JOIST HANGERS

Joist hangers for connecting floor joists to the rim member are available from various hardware manufacturers. Face-mount or top-mount hangers can be used.

Joist hangers are specified by the building designer based on the span and spacing of the supported joists (See Table 5). Joist hangers are required only at floor joists that land directly over the opening or immediately next to the opening or where the joist bearing on the top plate is less than the minimum required of 1-1/2 in. for solid sawn lumber or 1-3/4 in. for engineered I joists.

Factors that affect hanger selection also include the thickness and material of the supporting member (rim joist). When selecting a top-mount hanger for use with a single rim, verify that the top flange does not exceed the thickness of the rim. Face nails should have appropriate length based on the rim header thickness or should be clinched. Shorter nails (1-1/2 in. and 2-1/2 in.) for use with single or double rim joists are available from joist hanger manufacturers. A reduction in capacity of the joist hanger may be required for clinched or short nails (refer to joist hanger manufacturer specifications for the reduction factors).

**Table 5. Minimum Joist Hanger Design Value (Allowable Load)**

| Maximum Joist Span | Joist Spacing | |
|---|---|---|
| | 16 in. | 24 in. |
| 12 ft | 420 lb | 630 lb |
| 16 ft | 560 lb | 830 lb |
| 20 ft | 700 lb | 1,040 lb |
| Based on floor live load of 40 psf and floor dead load of 12 psf. | | |

**Joist hanger required if:**

- Joist located over opening, or
- Joist bearing on top plate is less than 1-3/4 in.

**Note:**

- Select the bracket for load
- Select nails based on manufacturer requirements and rim board thickness
- Install according to manufacturer requirements
- Adhesive in stirrup can help mitigate floor squeaks

## KING STUDS SUPPORTING RIM HEADERS

Unlike conventional headers located below the floor and supported by jack studs (i.e., partial height studs), rim headers are supported by king studs (i.e., full-height studs). King studs in this application serve the dual function of supporting the rim header and providing plate-to-plate continuity at the window boundaries. **In accordance with the IRC, the number of king studs on each side of an opening should not be less than the number of studs displaced by half the opening based on the maximum allowed stud spacing.** Table 6 provides the king stud requirements for specific window openings supported by 2x6 king studs based on the 2015 IRC requirements.

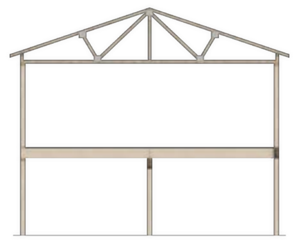
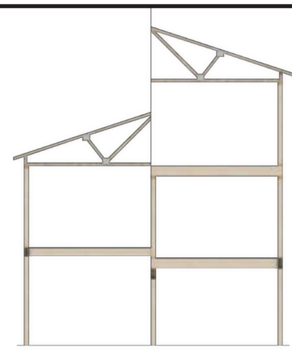
**Rim header installation is similar to common floor joist to girder installation**


**A.** Install brackets on floor joists over opening, and fully nail bracket using manufacturer recommended nails

**B.** Double rim (inside rim board) extends over king stud by at least 6 in.

**C.** Design loads determine the number of king studs required

**Table 6. 2x6 King Studs Supporting Rim Header**

| Minimum Number of King Studs on Each Side of Opening | | | |
|---|---|---|---|
| Structure Supported by Rim Header[A] | | Opening Width (ft) | 2x6 King Studs Each Side |
| Roof, ceiling, wall, and one half-span floor (stud layout framing at 24" oc with center beam) |  | 4 | 1 |
| | | 6 | 2 |
| | | 8 | 2 |
| | | 10 | 2 |
| | | 12 | 3 |
| Roof, ceiling, walls, and EITHER one clear span floor OR two half-span floors (stud layout framing at 16" oc with center beam) |  | 4 | 1 |
| | | 6 | 2 |
| | | 8 | 3 |
| | | 10 | 4 |
| | | 12 | 4 |

[A] 36 feet maximum roof span.

## ENGINEERED WOOD RIM HEADER

Engineered wood rim headers provide a greater spanning capacity than solid sawn lumber. Building codes and industry standards do not provide prescriptive spans for engineered wood headers because such products are proprietary and each manufacturer may offer a specific selection of sizes and design capacities. Various engineered wood products can be used in a rim header application: rated rim board product, structural composite lumber (SCL), laminated veneer lumber (LVL), or other wood composite products rated for bending applications under vertical loads. Contact the product manufacturer for information on prescriptive spans for its engineered wood products or for bending properties for use in engineered design. Similar to solid sawn lumber, the number of rim joist plies can be increased at the opening as needed to develop the minimum capacity for transferring the design loads to the supporting king studs. Table 7 (one-ply) and Table 8 (two-ply) provide example prescriptive tables for a 1-1/4 in. LSL rim board with the key bending characteristics as listed in the tables. Table 9 (one-ply) and Table 10 (two-ply) provide example prescriptive tables for a 1-1/8 in. rim board product based on the bending characteristics listed in the tables.

## SOLID-SAWN LUMBER RIM HEADER

Selecting appropriate solid sawn rim header is easy – use the same prescriptive header tables that are used for conventional single or multi-ply headers. The same header is now located above the wall's top plate instead of below it.

**Table 7. 1-1/4 in. LSL Rim Member (Fb=1,700 psi, Fv=425 psi, E=1.3x106 psi) – Single Ply, Maximum Opening (ft-in.)**

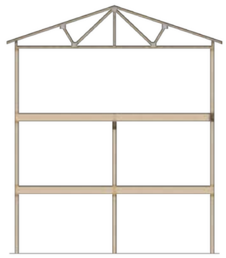
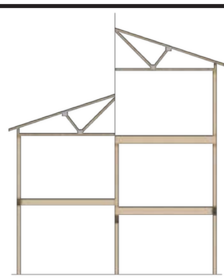
| Structure Supported by Rim Header | | Rim Member Size | 30 psf Ground Snow Load | | | 50 psf Ground Snow Load | | |
|---|---|---|---|---|---|---|---|---|
| | | | Building Width (Roof Span), ft | | | | | |
| | | | 20 | 28 | 36 | 20 | 28 | 36 |
| Roof, ceiling, wall, and one half-span floor |  | 1-1/4 x 9.5" | 6-9 | 5-9 | 5-2 | 6-1 | 5-2 | 4-7 |
| | | 1-1/4 x 11.875" | 7-11 | 6-10 | 6-1 | 7-2 | 6-2 | 5-5 |
| Roof, ceiling, walls, and EITHER one clear span floor OR two half-span floors |  | 1-1/4 x 9.5" | 6-0 | 5-2 | 4-7 | 5-10 | 5-0 | 4-5 |
| | | 1-1/4 x 11.875" | 7-1 | 6-1 | 5-5 | 6-11 | 5-11 | 5-3 |

**Table 8. 1-1/4 in. LSL Rim Member (Fb=1,700 psi, Fv=425 psi, E=1.3x106 psi) – Two Ply, Maximum Opening (ft-in.)**

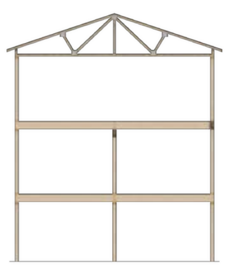
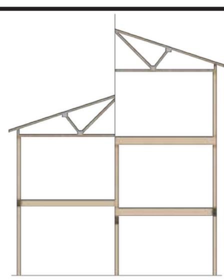
| Structure Supported by Rim Header | | Rim Member Size | 30 psf Ground Snow Load | | | 50 psf Ground Snow Load | | |
|---|---|---|---|---|---|---|---|---|
| | | | Building Width (Roof Span), ft | | | | | |
| | | | 20 | 28 | 36 | 20 | 28 | 36 |
| Roof, ceiling, wall, and one half-span floor |  | (2) 1-1/4 x 9.5" | 9-5 | 8-2 | 7-4 | 8-7 | 7-4 | 6-6 |
| | | (2) 1-1/4 x 11.875" | 11-3 | 9-8 | 8-7 | 10-1 | 8-8 | 7-9 |
| Roof, ceiling, walls, and EITHER one clear span floor OR two half-span floors |  | (2) 1-1/4 x 9.5" | 8-6 | 7-4 | 6-6 | 8-3 | 7-1 | 6-4 |
| | | (2) 1-1/4 x 11.875" | 10-0 | 8-7 | 7-8 | 9-9 | 8-4 | 7-5 |

**Table 9. 1-1/8 in. Rim Member (Fb=600 psi, Fv=270 psi, E=0.55x106 psi) - Single-Ply, Maximum Opening (ft-in.)**

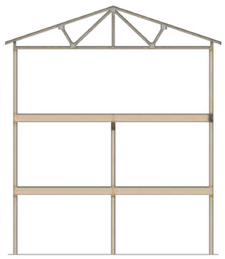
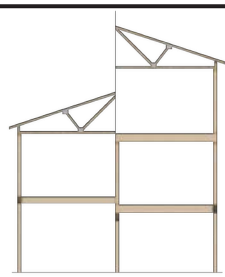
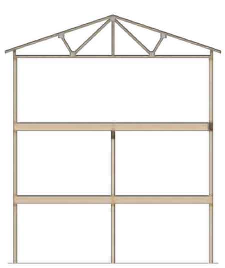
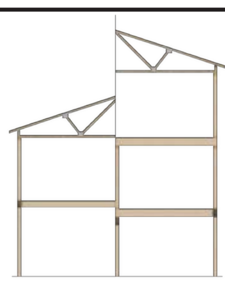
| Structure Supported by Rim Header | | Rim Member Size | 30 psf Ground Snow Load | | | 50 psf Ground Snow Load | | |
|---|---|---|---|---|---|---|---|---|
| | | | Building Width (Roof Span), ft | | | | | |
| | | | 20 | 28 | 36 | 20 | 28 | 36 |
| Roof, ceiling, wall, and one half-span floor |  | 1-1/8 x 9.5" | 3-9 | 3-3 | 2-11 | 3-5 | 2-11 | 2-7 |
| | | 1-1/8 x 11.875" | 4-0 | 3-10 | 3-5 | 4-0 | 3-5 | 3-1 |
| Roof, ceiling, walls, and EITHER one clear span floor OR two half-span floors |  | 1-1/8 x 9.5" | 3-4 | 2-11 | 2-7 | 3-3 | 2-10 | 2-6 |
| | | 1-1/8 x 11.875" | 4-0 | 3-5 | 3-1 | 3-11 | 3-4 | 3-0 |
| Maximum opening is capped at 4 feet in accordance with manufacturer's installation recommendations. | | | | | | | | |

**Table 10. 1-1/8 in. Rim Member (Fb=1,700 psi, Fv=425 psi, E=1.3x106 psi) - Two-Ply, Maximum Opening (ft-in.)**

| Structure Supported by Rim Header | | Rim Member Size | 30 psf Ground Snow Load | | | 50 psf Ground Snow Load | | |
|---|---|---|---|---|---|---|---|---|
| | | | Building Width (Roof Span), ft | | | | | |
| | | | 20 | 28 | 36 | 20 | 28 | 36 |
| Roof, ceiling, wall, and one half-span floor |  | (2) 1-1/8 x 9.5" | 5-0 | 4-7 | 4-1 | 4-9 | 4-1 | 3-8 |
| | | (2) 1-1/8 x 11.875" | 5-0 | 5-0 | 4-10 | 5-0 | 4-11 | 4-4 |
| Roof, ceiling, walls, and EITHER one clear span floor OR two half-span floors |  | (2) 1-1/8 x 9.5" | 4-9 | 4-1 | 3-7 | 4-7 | 3-11 | 3-6 |
| | | (2) 1-1/8 x 11.875" | 5-0 | 4-10 | 4-4 | 5-0 | 4-9 | 4-2 |
| Maximum opening is capped at 5 feet in two-ply applications. | | | | | | | | |

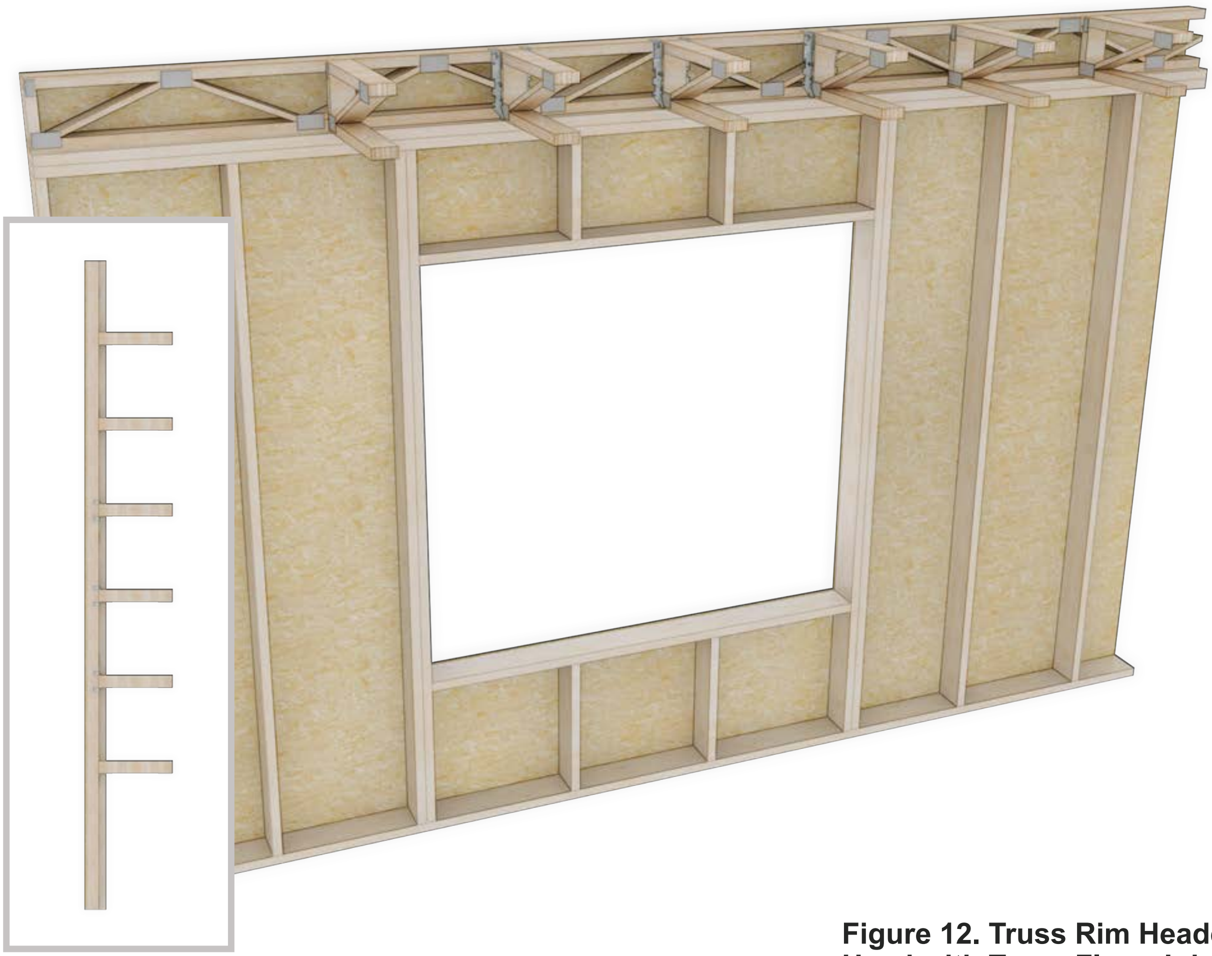


**Figure 12. Truss Rim Header Used with Truss Floor Joists**

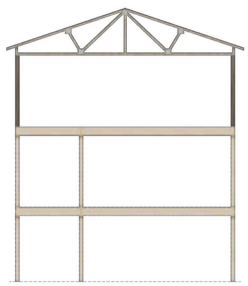
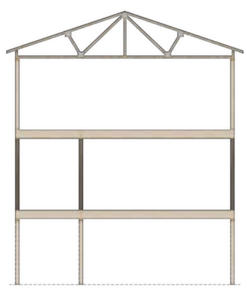
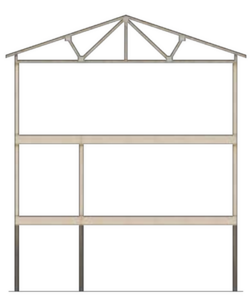
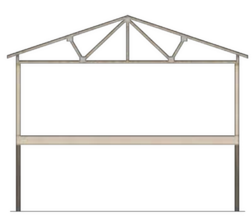
## TRUSS RIM HEADER

Metal plate connected wood trusses can be used as rim headers (see Figure 12). Trusses are engineered systems that must be approved by a licensed design professional. Top mount hangers are appropriate for supporting floor trusses. 2x6 walls allow for 2 in. of bearing adjacent to a truss rim header. Truss rim can be insulated with products like spray foam for minimized thermal bridging and improved air sealing. The exterior of the truss rim must be enclosed with exterior sheathing.

## JACK STUDS AND KING STUDS (APPLICATIONS OTHER THAN RIM HEADER)

The number of 2x6 jack studs and king studs should be determined in accordance with the governing building code. Table 11 provides the number of 2x6 jack studs for select window configurations and snow load levels. A single 2x6 jack stud is needed for 4-foot openings in most configurations. A double 2x6 jack stud is sufficient for most larger openings in a typical house.

Table 11. 2x6 Jack and King Studs (Applications Other than Rim Header)

| Supported Structure | Max Opening Width, ft | Min Number of Jack Studs — Roof Snow Load 30 psf | Min Number of Jack Studs — Roof Snow Load 50 psf | Minimum Number of King Studs |
|---|---|---|---|---|
| Roof and Ceiling  | 4 | 1 | 1 | 1 |
| | 6 | 1 | 2 | 2 |
| | 10 | 2 | 2 | 3 |
| Roof, Ceiling, and One Center Bearing Floor  | 4 | 1 | 1 | 1 |
| | 8 | 2 | 2 | 2 |
| | 10 | 2 | 3 | 3 |
| Roof, Ceiling, and EITHER One Clear Span Floor or Two Center-Bearing Floors | 4 | 1 | 2 | 2 |
|  | 8 | 2 | 2 | 3 |
|  | 10 | 3 | 3 | 4 |

For buildings with two or more stories, a combination of single headers at the top story and rim headers for the lower stories provides a practical option for energy efficient load-bearing walls (Figure 13).

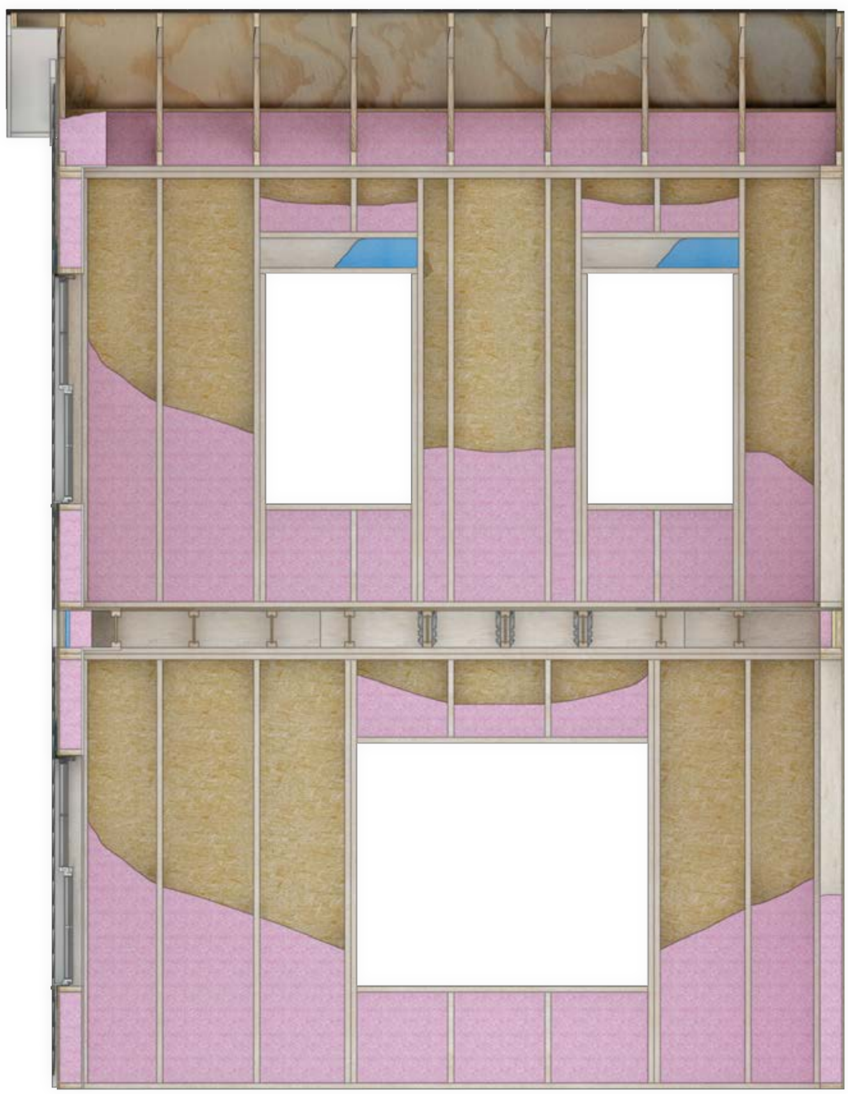


**Figure 13. 1st Floor Rim and 2nd Floor Single Headers**

# INSULATING RIM JOIST

Whether a standard rim joist or a rim header is used, it should be insulated to at least the same level as exterior walls – R20 for 2x6 walls in Climate Zones 3-5. Insulation can be installed on the interior or between the rim members (if double rim is used). Insetting the rim to accommodate exterior insulation is not a prescriptive option in the code and should not be used unless approved by a licensed professional.

Because the floor joist members are attached to the interior face of the rim every 16–24 in., rim areas are one of the more difficult areas of the structure to insulate and air seal. The following is a list of insulation options for the rim area.

### CLOSED CELL SPRAY FOAM

The closed cell spray foam serves a triple function of providing thermal, air, and vapor resistance. The spray application technology allows consistent installation between the floor joists and fills all joints, gaps, and corners (Figure 14). The minimum R20 can be achieved by a combination of 1 to 1-1/2 in. of closed spray foam and added batt insulation or 3-1/4 in. of closed cell foam (at R6.5 per inch). Note that the IRC requires a thermal barrier at the rim if a spray foam (or another foam plastic) exceeds 3-1/4 in. Open cell spray foam is a less practical option for the rim joist insulation due to its reduced thermal resistance and high vapor permeability.

**Figure 14. Spray Foam Insulation/Air Seal at Rim**

### RIGID FOAM SHEATHING SECTIONS

Rigid foam installed in square sections between the floor joists may be better suited for solid sawn lumber applications. If used with I-joists, the rigid foam sections have to accommodate the cross-sectional shape of the engineered joist members (Figure 15). A minimum of 1 in. thickness of rigid foam is recommended. The foam sections should be air sealed at the perimeter using caulk or other products.

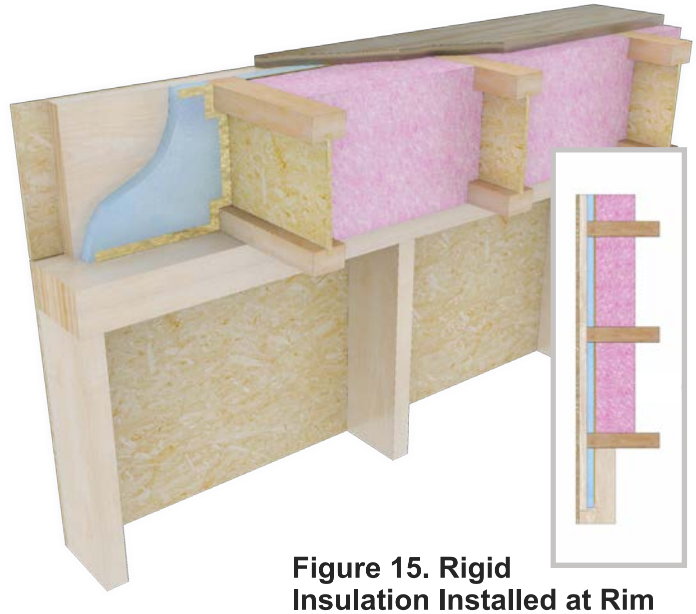


**Figure 15. Rigid Insulation Installed at Rim**

## FIBERGLASS BATT INSULATION

Using the same batt insulation at the rim that is used in walls provides a code-compliant option for insulating the rim area (Figure 16). Kraft facing (or functionally similar material) is always recommended for reducing air and vapor flow (see the Water Vapor Management section for more information on selecting vapor retarders). The primary limitation of this option is that it does not provide effective air sealing at the edges of the insulation. Consistency of insulation installation quality requires additional attention. The rim joist should be air sealed.

**Figure 16. Fiberglass Rim Insulation**

## PREFABRICATED INSULATED RIM JOIST

Proprietary insulated rim joist products (Figure 17) are now commercially available. A prefabricated insulated rim typically consists of an exterior rim joist member (engineered wood) and an interior layer of OSB with a rigid foam layer in between. The purpose of the interior OSB layer is to provide torsional stability for the I-joists during installation (stability against twisting under load). To allow for the minimum required I-joist bearing of 1-3/4 in., the total thickness of the composite rim member cannot exceed 3-3/4 in. in a 2x6 wall. Therefore, the practical total R-value for this type of product ranges from R8 to R14. Air sealing at the rim interfaces is also recommended.

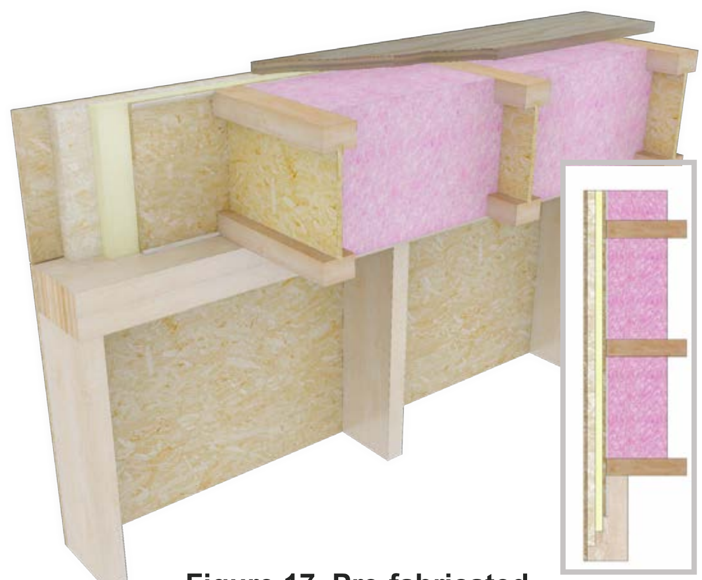


**Figure 17. Pre-fabricated Insulated Rim**

## CONTINUOUS INTERIOR RIGID FOAM

A one- to 2 in. layer of rigid foam is installed between the rim member and the floor joist. To provide torsional stability for the floor member, this option relies on the wood subfloor nailed to the rim joist and the floor joist. Currently, this option is recommended only for use with engineered wood trusses (Figure 18) or solid lumber joists (Figure 19) both of which have torsional resistance higher than engineered wood I joists.

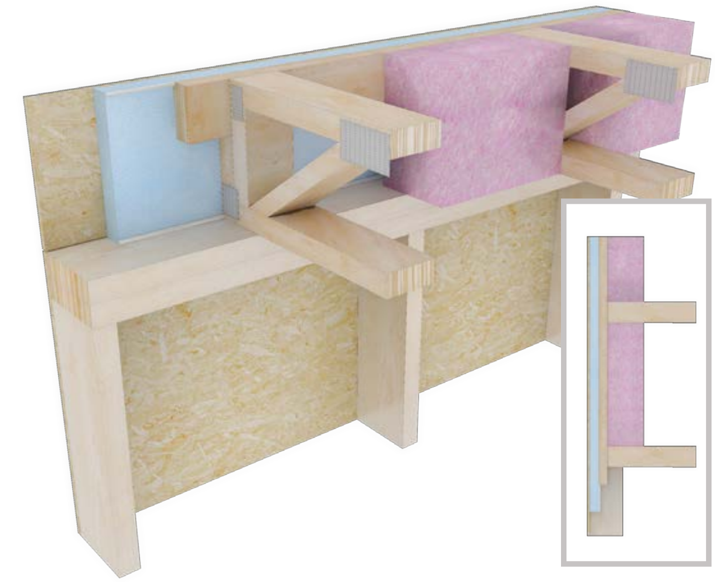


**Figure 18. Section of Insulated Rim**

**Figure 19. Section of Insulated Rim**

# MODULAR LAYOUT OF OPENINGS

By placing wall openings on 24 in. or 16 in. modules, the wall layout studs can be used as part of the window or door framing:

- Minimizing the total number of studs required to frame the wall;
- Avoiding narrow stud cavities that are difficult to insulate; and
- Reducing labor-intensive details for the framer, mechanical trades, and insulator.

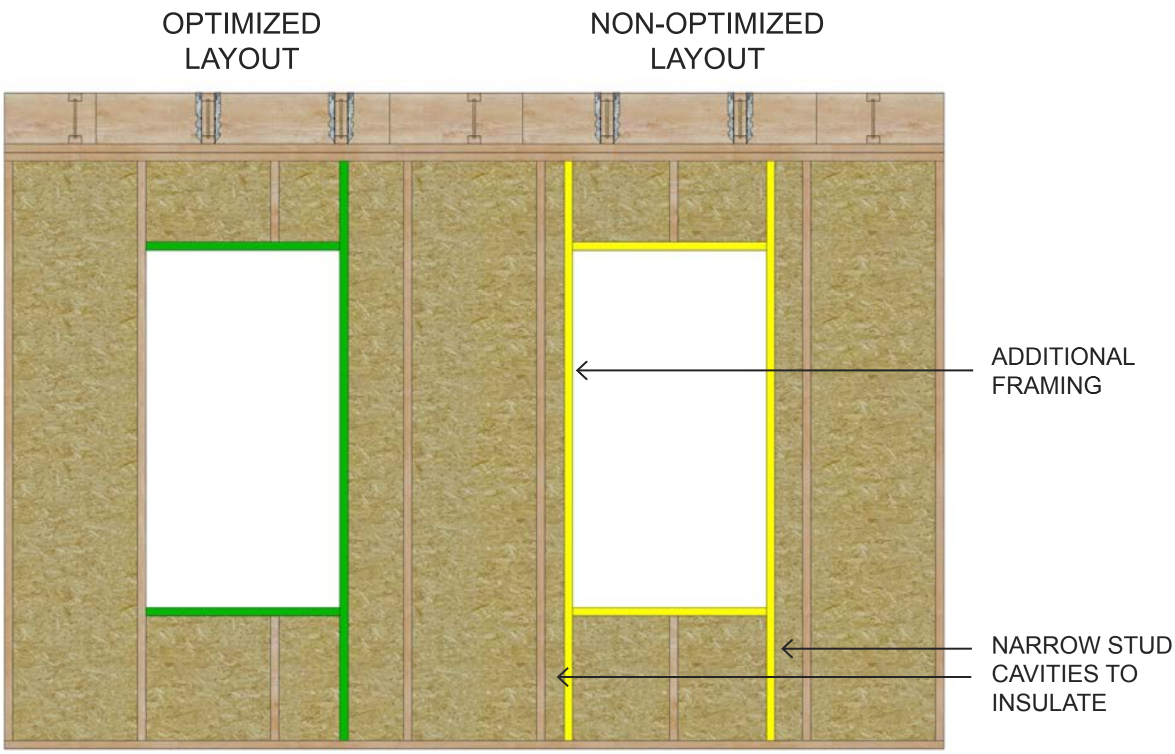



**Figure 20. Optimized Framing Layout**

Figure 20 graphically compares a modular placement of windows in a wall with 24 in. on center studs to an “uncoordinated” window placement. Fewer studs are necessary and narrow stud cavities are minimized. Although architectural considerations may not permit the use of the modular layout for every opening, evaluation of window and door placement early in the design phase can help to reduce thermal bridging, improve resource efficiency, and maintain cavity width for insulation.

# EXTERIOR WALL SHEATHING

Wood structural panel sheathing can be installed on framing spaced 16 or 24 in. on center. Table 12 provides a range of installation options based on the stud spacing, fastener size, and WSP rating. Table 12 is based on the prescriptive IRC schedule with maximum spacing of 6 in. on the panel perimeter and 12 in. in the panel field. For 24 in. stud spacing, 6d common nails are not permitted by the prescriptive IRC provisions. For wind exposure C, 3/8-in.-thick WSP rated 24/0 are not permitted at 24 in. stud spacing. For both OSB and plywood products, panel thickness category and panel rating are stamped on each panel. Panels can be installed vertically or horizontally (if installing panel horizontally, blocking may be required to comply with braced wall requirements and additional sealing measures will be needed at the horizontal joints).

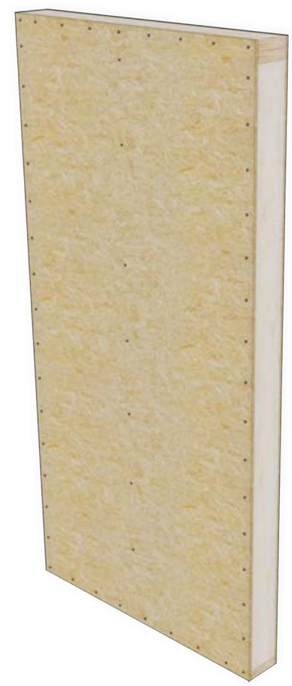


**Table 12. Wood Structural Panel Installation for Studs Spaced at 24 and 16 in. On Center**

| Maximum Wind Speed (mph) and Wind Exposure Category[A,B,C,D] | | | | | |
|---|---|---|---|---|---|
| | | Sheathing Nail | | | |
| Stud Spacing | Panel Thickness, WSP Rating | 6d common (2.0"x0.113") | 8d box (2.5"x0.113") | 8d cooler (2.375"x0.113") | 8d common (2.5"x0.131") |
| 24" | 3/8" Wall 24, 24/0 | N/P | 100B | 100B | 100B |
| 24" | 7/16" 24/16 | 90B | 110B 90C | 105B 90C | 110B 90C |
| 16" | 3/8" Wall 16, 24/0 | 110B 90C | 110B 90C | 110B 90C | 110B 90C |
| 16" | 7/16" 24/16 | 110B 100C | 130B 110C | 130B 110C | 130B 110C |

[A] Maximum nail spacing: 6 in. on center at panel edges and 12 in. on center in panel field.
[B] See the IRC for the Basic Wind Speeds map and Exposure Categories.
[C] WSP rating is stamped on the panel.
[D] Panels can be installed vertically or horizontally.

# INTERIOR GYPSUM SHEATHING

The minimum thickness for gypsum board, installed either vertically or horizontally, used with 24 in. on center studs is 1/2 in. Installation can be with or without adhesive. Where 1/2 in. gypsum is attached using screws only (without adhesive), the maximum screw spacing is reduced from 16 in. to 12 in. on center. Other gypsum board panel installation practices for 24 in. on center stud spacing are the same as for 16 in. on center stud spacing (see Table 13). Consumers are already familiar with the performance of 1/2 in. gypsum board panels installed at 24 in. on center in partition applications. In addition, 1/2 in. drywall is commonly used in ceiling application with metal plate connected trusses spaced at 24 in. on center where the gypsum board panels are subject to gravity load from the weight of insulation and its own weight. Where there is a consumer perception that 1/2 in. gypsum board panels are not sufficiently rigid for 24 in. on center stud spacing, 5/8 in. gypsum can be installed as an alternative. Note that 3/8 in. gypsum board is not permitted with 24 in. on center stud spacing.

Some builders note that in some applications, glued drywall installation may be better suited for 24 in. on center framing because it is more forgiving to framing's settlement/movement and to installation tolerances.

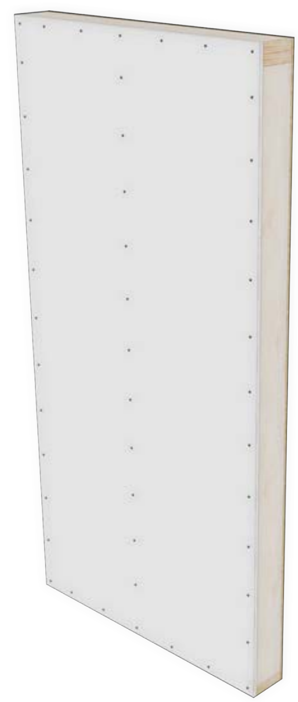


**Table 13. Gypsum Board Installation for Studs Spaced at 24 and 16 in. On Center - Maximum Spacing of Fasteners (in.)**

<table>
<tr><th rowspan="2">Gypsum Board Thickness</th><th rowspan="2">Gypsum Board Attachment</th><th colspan="2">Maximum Stud Spacing</th></tr>
<tr><th>24 in.</th><th>16 in.</th></tr>
<tr><td rowspan="4">1/2" or 5/8"</td><td>Nails only</td><td colspan="2">8"</td></tr>
<tr><td>Nails and adhesive</td><td colspan="2">16"</td></tr>
<tr><td>Screws only</td><td>12"</td><td>16"</td></tr>
<tr><td>Screws and adhesive</td><td colspan="2">24"</td></tr>
<tr><td colspan="4">Note: 3/8 in. gypsum wall board is not permitted with 24 in. on center stud spacing. Refer to the IRC for fastening requirements for 3/8 in. gypsum at 16 in. on center.</td></tr>
</table>

# CAVITY INSULATION

A range of cavity insulation products is available for 2x6 wall construction in either 24 in. or 16 in. on center stud spacing applications. All insulation products listed in Table 14 meet the prescriptive IRC wall insulation requirements for Climate Zones 3-5.

**Table 14. Common Framed Wall Cavity Insulation Options for 2x6 Framing**

| Insulation | Total 5.5" cavity R-value | Approx. R-value/in. | Notes |
|---|---|---|---|
| Fiber glass batt[A] | 20 | 3.6 | Batts available for 16" or 24" stud spacing. Batt insulation is most effective with a Grade 1 installation[E] |
| | 21 | 3.8 | |
| Spray-applied fiber glass | 23 | 4.2 | Applicable to any stud spacing. Dense packing may require rolling insulation flat prior to drywall installation. |
| Spray-applied cellulose | 21 | 3.8 | |
| Cellulose (dense pack) | 20 | 3.7 | |
| Mineral wool batts | 22 | 4.0 | Batts available for 16" or 24" stud spacing |
| | 24 | 4.4 | |
| Open Cell Spray Foam (ocSPF)[B] | 20 | 3.7[B] | Applicable to any stud spacing |
| Closed Cell Spray Foam (ccSPF)[C] | 32 | 6.5 | |
| Hybrid ccSPF + Spray FG | 25 | 4.5[D] | |

[A] R20 batts currently have limited availability and product options. Both R20 and R21 are 5.5 in. thick to be used uncompressed in 2x6 framing.
[B] Refer to the foam supplier for installation guidelines for achieving the prescriptive IRC minimum of R20.
[C] Installed average thickness approximately 5 in.
[D] Average from 1 in. ccSPF and 4.5 in. Spray FG at <2.0 pcf.
[E] Grade 1 batt installation requires that the insulation material uniformly fill each cavity side-to-side and top-to-bottom, without substantial gaps, or voids around obstructions (such as blocking or bridging), and be split, installed, and/or fitted tightly around wiring and other services in the cavity. To attain a rating of Grade I, wall insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity.

Fiber glass batts are available with or without Kraft facing (Class II vapor retarder). Other insulation types do not include options for integrated vapor retarders. See Vapor Retarder section for more information.

Where batt insulation is used, 24 in. on center stud spacing reduces the number of batts per linear foot of wall reducing the installation labor. The increased cavity depth of 2x6 walls allows for better insulation installation quality at corners, intersections, electrical boxes, etc.

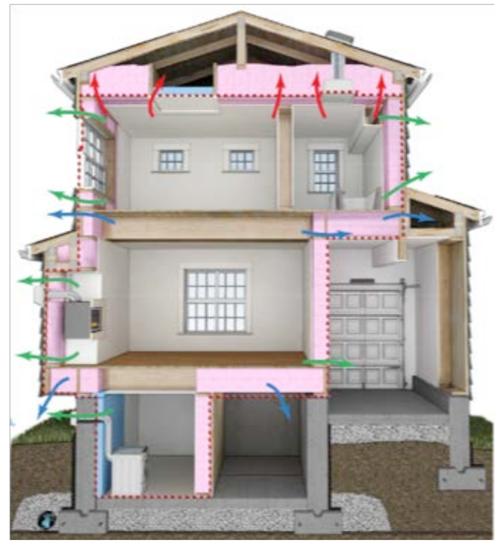
# AIR SEALING

***Switching to the 2x6 wall system can be easily complemented by enhanced air sealing strategies to further improve the energy efficiency and to meet more stringent whole-house air tightness requirements.***

Improving the air-sealing of the wall system not only reduces thermal losses due to air leakage, but also limits air movement into the cavity, reducing moisture loads (from the water vapor entrained in the air) into the wall cavity.

Wall air sealing measures are a major part of a whole-house air sealing package. However, other systems and elements of the building and their junctions must be adequately air-sealed to ensure the overall air tightness of the building. As defined in the IRC, the air barrier consists of “material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.” Multiple layers of the wall system make up the air barrier system of the home. Table 15 summarizes the IRC air barrier requirements relevant to exterior walls.

## Table 15. Wall Air Sealing Measures Outlined in the IRC[A]

<table>
<tr><th>Component</th><th>Notes</th><th>Air Boundary</th></tr>
<tr><td>Air barrier (general)<br>A continuous air barrier shall be installed in the building envelope.<br>Exterior thermal envelope contains a continuous air barrier.<br>Breaks and joints in the air barrier shall be sealed.</td><td>All exterior framing components and layers can perform an air barrier function. The code does not specify the location of the air barrier within a component (e.g., wall) so multiple approaches may be used effectively.</td><td rowspan="7"><br>Ceilings<br>• Top plates<br>• Access panel<br>• Penetrations – bath fans, duct boots, electrical<br>• Framed cavities – above kitchen cabinets, soffits, & chases<br>Walls<br>• Bottom plate at deck/slab<br>• Penetrations<br>• Sheathing<br>• Windows & doors<br>• Garage-side drywall<br>• Knee-wall air barriers<br>• Behind tubs & stairs<br>• Framed cavities - within chases & bulkheads<br>Fireplaces<br>• Behind pre-fabricated fireplaces<br>• Around dampers & vents<br>Rim Joist Areas<br>• Rim-board - joist cavity<br>• Sill plate at foundation<br>• Draft stops at garage & knee walls<br>Floors<br>• Cantilevered<br>• Above garages, vented crawl spaces, & conditioned basements</td></tr>
<tr><td>Walls<br>The junction of the foundation and sill plate shall be sealed.<br>The junction of the top plate and top of exterior walls shall be sealed.</td><td>The exterior wall boundaries at the foundation and at the roof are required to be air sealed. Air sealing can be accomplished either from the exterior or interior, or both.</td></tr>
<tr><td>Windows and doors<br>The space between window/door jambs and framing shall be sealed.</td><td>Use of low expansion foam is the most effective method for these narrow spaces.</td></tr>
<tr><td>Rim joist<br>Rim joists shall be insulated and include the air barrier.</td><td>The rim joist is required to be part of the continuous air barrier.</td></tr>
<tr><td>Penetrations<br>Utility penetrations to the exterior or unconditioned space shall be sealed.</td><td>Penetrations should be sealed at exterior sheathing and preferably also at the interior sheathing.</td></tr>
<tr><td>Shower/tub on exterior wall<br>Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating (exterior walls) from the showers and tubs.</td><td>Showers/tubs cannot be installed directly against framing.</td></tr>
<tr><td>Fireplace<br>An air barrier shall be installed on fireplace walls.</td><td>The fireplace insert is built into a wall bump-out and therefore is part of the conditioned space. The walls of the bumpout must be insulated and airsealed.</td></tr>
</table>

**[A] Refer to Table N1102.4.1.1 of the IRC.**

## APPROACHES TO WHOLE-HOUSE AIR SEALING

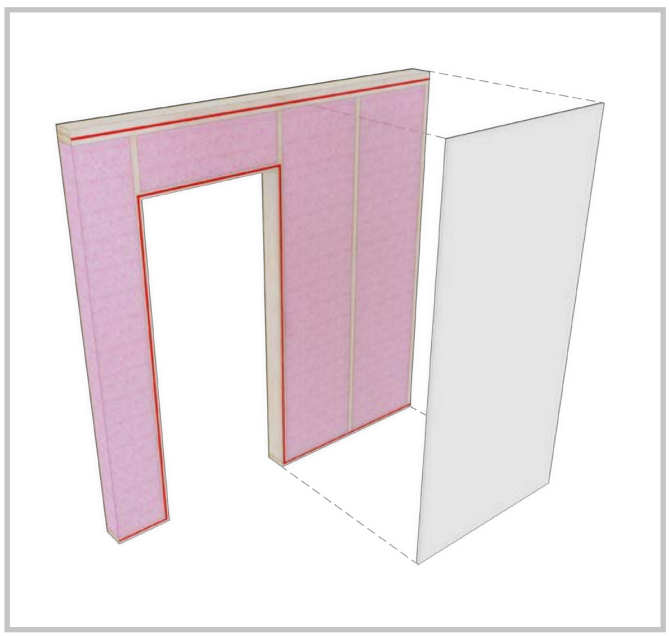
Establishing the building's air barrier perimeter is now understood as a fundamental approach to high performance home construction. For quality management purposes, the air barrier of the building envelope can be detailed on the plans so that trades are familiar with the location of the air barrier when constructing walls. This is particularly important for complicated framing details. The IRC[1] provides specific details for air sealing to establish some consistency for the trades and builders in identifying and creating an air barrier perimeter. There are three primary reasons for developing the air barrier perimeter using various air-sealing approaches that make it fundamental to the construction process:

- Limit large air leakage pathways that carry moisture laden air to condensing surfaces;
- Maintain R-value levels of permeable insulation materials degraded by air movement; and
- Limit energy losses due to conditioned air leakage out of the home.

***The air barrier for framed exterior walls may be located to the exterior, the interior, or a combination of both:*** Air barriers located to the exterior, for example using a weather resistive barrier (WRB) such as house wrap over structural sheathing, limit air leakage from the outside that can degrade the effectiveness of air permeable insulation (fiberglass, cellulose, mineral wool). Air barriers located to the interior, for example sealed gypsum board, can limit air leakage into the cavity from the inside that can carry moisture, and limit air leakage to the attic space. ***Ideally, a combination of air sealing strategies and materials are used to provide multiple benefits. For measures that involve air sealing within the cavity, 24 in. on center stud spacing simplifies the sealant application process due to the reduced number of framing members that require sealing or obstruct the access for application of sealing.***

## APPROACHES TO ACHIEVING AN EFFECTIVE WALL AIR SEALING:

- **Air sealing at interior sheathing (air-sealed drywall)**
  - A sealant (caulk, glue, foam adhesive, etc.) is applied at the top and bottom plates and at the perimeter of all openings and penetrations on the interior face of the framing creating a gasket between the framing and the drywall.
  - Sealing drywall minimizes the air-flow into the cavity from the interior during the heating season helping to control against condensation and against elevated moisture content of the framing and exterior sheathing.
  - Air sealing at the top plate of the top story also minimizes leakage into the attic.
  - No reliable method for inspecting or controlling the quality of the seal after the installation of the panel.
  - Dried or hardened sections of adhesive prior to drywall installation may increase air leakage.
  - Uneven or missing sections of caulk or adhesive may increase air leakage.
  - May slow the installation of the drywall.

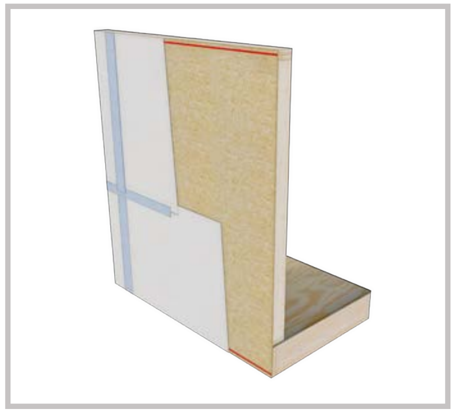


[1] IRC Table N1102.4.1.1

- **Air sealing at wall's exterior – air sealed sheathing**
  - A gasket is installed at the top and bottom plates and at the perimeter of all openings on the exterior face of framing before installation of the wood structural panel (this technique is more suitable for applications where the sheathing is attached to framing in a horizontal position before the panels are stood up for installation (i.e., factory or site panelization rather than applying sheathing to framing in place in a vertical position).
  - The thickness of the gasket (after the sheathing is fastened to framing) should not exceed 1/16 in. to avoid impact on the shear wall performance.
  - The vertical edges of the abutting exterior sheathing panels should be also be caulked or sealed from the exterior.
  - Sealing at the exterior does not limit air movement from the building interior into the cavity that can result in an increased moisture loading during the heating season.
  - No reliable method for controlling the quality of the seal provided by the gasket after the installation of the sheathing panels.
  - The top plate of the top story wall should be air sealed at the drywall to prevent air leakage into the attic.

- **Air sealing in cavity (picture-frame air sealing)**
  - A sealant (caulk, spray, etc.) is applied in the wall cavity at the panel to framing interface (often referred to as a picture-frame method).
  - This method's performance attributes are similar to air sealing at wall's exterior (see above) except quality of the air seal can be visually inspected.
  - There is an air path between the stud and the plates not captured by the picture-frame approach and requires sealing at the exterior or interior face of the plates.
  - An alternate approach to the "picture frame" method is to install a layer of closed cell spray foam to fully cover the sheathing in the cavity.

- **Air sealing at wall's exterior – air sealed WRB**
    - WRB taped at all joints provides an air barrier that reduces the infiltration of the exterior air into the cavity. House wraps should be rated as an air barrier material (perforated house wraps typically do not meet this requirement).
    - The WRB also has to be sealed to the exterior sheathing or framing at the top and bottom of the wall to provide a continuous air barrier – when tapes are used in such application, it should be verified that the tapes are intended for adhesion to wood products and at the appropriate temperature (may require a primer).
    - Penetrations of the siding fasteners through the WRB result in some air leakage.
    - Air sealed WRB may not be sufficiently effective to be used as the only method for creating a continuous air barrier, but it can be combined with other are sealing measures to form a complete wall air sealing system.
    - Sealing at the exterior does not limit air movement from the building interior into the cavity that can result in an increased moisture loading during the heating season.



- **Air sealing at wall's exterior –** proprietary hybrid systems
    - Proprietary sheathing panel systems are available in the market that combine the structural panel function with the WRB function and use tapes on the exterior of the panel to provide a water resistant air-tight joint. Manufacturers of such systems should be contacted for information on their performance attributes and installation recommendations.
- **Combination approach**
    - Elements of different air sealing strategies can be combined to further reduce air infiltration.
    - ***A combination of exterior and interior air sealing results in maximum thermal and moisture performance by limiting air movement into the cavity from the indoors and outdoors.***

The key attributes of the various air sealing strategies are summarized in Table 16.

**Table 16. Summary of Air Sealing Strategies**

| Air Sealing Approach | Pros | Cons | Performance |
|---|---|---|---|
| Exterior only | Simple, additional interior details at the ceiling to the attic for sealing required | Does not limit air movement from indoors into cavity | Good |
| Cavity only (exterior) | Good quality control (easily inspected after sealing and before insulation) | Does not limit air movement from indoors into cavity | Good (picture frame option)<br>Better (ccSPF option) |
| Interior only | Controls infiltration of interior humid air into the cavity. Controls leakage into the attic | Potential for infiltration of the outdoor air into the cavity | Better |
| Combination | Opportunity to find an optimum solution based on features of both | Additional cost | Best |

# WATER VAPOR MANAGEMENT

The vapor retarder selection for 2x6 walls varies by climate zone, the type of insulation, and the cladding system. Table 18 and Table 19 outline cladding types, drying potential, and vapor retarder recommendations for Climate Zones 3 to 5 (Figure 21). Advanced framing and stud spacing does not influence vapor retarder selection. Walls with exterior foam are addressed in Part II of the Guide.

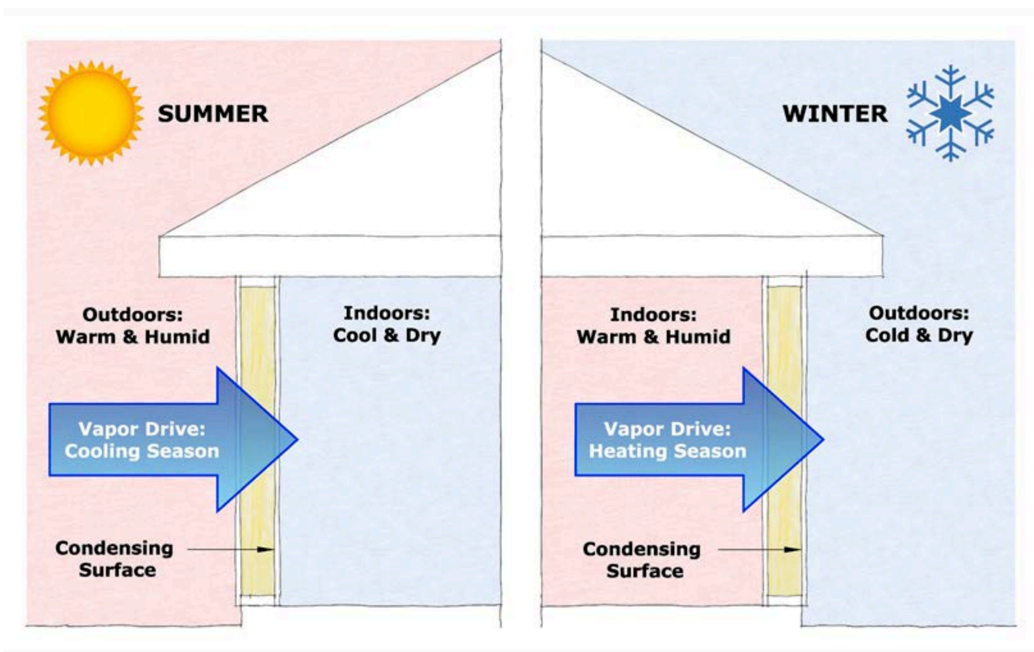
***Vapor retarders for Climate Zones 3 through 5 should be located on the interior of the wall or, if within the cavity, integrated with an insulating product (e.g., ccSPF).***

Vapor retarders are used primarily in cold climates to prevent moisture present in warm indoor air (as water vapor) from entering wall assemblies and condensing on cold exterior sheathing.  Moisture can enter walls (from indoors and outdoors) as water vapor by diffusion or air leakage. It is important that both moisture migration paths are managed to reduce the risk of moisture issues. Vapor retarders are used to manage vapor diffusion. Some vapor retarder membranes help with controlling air flow as well. The reader is referred to the Air Sealing section for information on practices for controlling air leakage.

A vapor management strategy should balance limiting vapor diffusion into the wall and allowing the wall to dry out should any incidental moisture accumulate in the cavity. The first is achieved by selecting an appropriate interior vapor retarder (or installing a layer of exterior insulation – addressed in Part 2 of this Guide) to limit the vapor drive. The second is achieved by ensuring that at least one face of the wall is constructed with moderate-to-high permeability materials to avoid a double vapor barrier condition.

### VAPOR DRIVE

During heating season in cold climates, vapor drive is predominantly outward—from indoors to outdoors through the wall assembly—with the risk of water accumulation and condensation on the cold exterior sheathing. During cooling season in warm-humid climates, vapor drive is predominantly inward with the risk of condensation on the cool drywall surface. In mixed-humid climates, vapor drive occurs in both directions depending on the season, and to some degree in both cold and warm-humid climates as well.



Based on their effectiveness, vapor retarders are assigned into three classes as outlined in Table 17.

**Table 17. Vapor Retarder Classification**

| Class | Vaper Permeability | Permeance Range | Example Materials review |
|---|---|---|---|
| Class I | Low – impermeable | ≤0.1 perm | polyethylene sheet (poly), aluminum foil (non-perforated) |
| Class II | Medium – semi-impermeable | >0.1 and ≤1.0 | Kraft paper, ccSPF at ≈1.5-2.5" thickness (see manufacturer product data), OSB at <85% RH |
| Class III | Medium to High – semi-permeable | >1.0 and ≤10 | Latex or enamel paint (rated[A]), Kraft paper at higher RH, OSB at >85% RH |
| N/A | High – permeable | >10 | Gypsum (unpainted or non low-perm paint), smart vapor retarder at higher RH |

[A] Paint should be tested to demonstrate permeability properties at application thicknesses. Typical primer/finish coat wall paint coverings may not consistently meet Class III permeance levels.

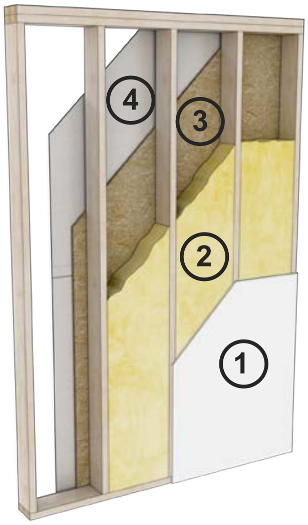
**PERM** is a measure of the amount of water vapor (in units of grain) transmitted through a square foot area of material per hour under a pressure equal to an inch of mercury. As a reference point, at interior conditions of 40% relative humidity and 70°F and exterior average monthly dew point temperature of 33°F, as much as 8.5 quarts of water can get through a 4x8 sheet of gypsum (50 perms) in a month. Replacing gypsum with Kraft paper (1 perm) reduces that amount to 0.17 quarts of water.

**SMART VAPOR RETARDERS** are vapor retarders that change permeance in a manner that allows vapor diffusion to facilitate drying when elevated levels of moisture occur and minimize vapor diffusion under normal conditions. Permeance in such materials is a function of relative humidity. With elevated relative humidity the permeance increases, and vice versa. Some traditional materials (typically wood-fiber based) exhibit smart vapor retarder characteristics (e.g., Kraft paper). There are proprietary materials with properties specifically engineered to respond as smart vapor retarders. When selecting a proprietary Smart Vapor Retarder, follow manufacturer's guidance for the product for meeting the code provisions for vapor retarders for the specific application (i.e., climate zone, wall configuration).

***Drying of any water accumulated in the sheathing and framing can be directed to the outside and/or to the inside of the building. Therefore, selection of the interior vapor retarder Class depends on the ability of the wall to dry to the outside.*** For walls with cladding systems that substantially impede drying to the outside (see Table 18), Class I interior vapor retarders are not recommended for any climate zone to avoid creating a "double" vapor barrier configuration where any water accumulated inside the wall does not have at least one potential exit path (see Table 19).

In **Climate Zone 3** (or warmer climate zones), the IRC does not require an interior vapor retarder because the vapor drive from the interior to the outdoors during the colder season is not significant enough. Installing a Class I interior vapor retarder is not recommended because of the substantial summer vapor drive in this climate zone from the outdoors to the indoors that can lead to potential for condensation on the cold interior surface (air-conditioned side of the wall) leading to trapped moisture.

### Example Wall Assembly without Vapor Retarder




This figure shows an example wall assembly with vented cladding and no interior vapor retarder

- This wall allows drying in both directions.
- The types of vented cladding could include vinyl lap siding, brick veneer, and cement board or wood lap siding over furring strips.
- This wall assembly is recommended in warm-humid climate zone 3A below the warm-humid line.
- Non-vented cladding may be substituted in this climate.

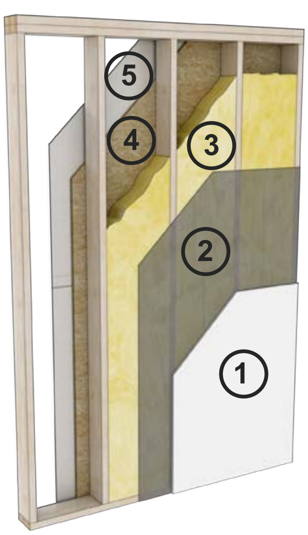
Example wall assembly:

1. Painted drywall (standard paint)
2. Wall cavity insulation (permeable)
3. OSB structural sheathing
4. Vented cladding and WRB

Similarly, the IRC does not require an interior vapor retarder in **Climate Zone 4** (except 4C, marine). ***Per this Guide, in walls with air permeable insulation, some water vapor control measure is recommend for Climate Zone 4***. The recommended vapor control measures include a Class III (e.g., vapor retarder paint) or Class II (e.g., Kraft-faced batts). In addition to or in lieu of the vapor retarder, drywall air sealing measures on the interior of the wall can be implemented to minimize water vapor load delivered by bulk air leakage from the interior into the cavity.

**In Climate Zones 4C and 5**, the 2012/2015 IRC requires a Class I or Class II vapor retarder but permits Class III with vented cladding (or sufficient continuous exterior insulation - see Part 2 of the Guide). This Guide recommends a Class II vapor retarder for Climate Zones 4C and 5 as the preferred strategy that provides sufficient degree of vapor diffusion control yet it provides some drying ability. ***As with other climate zones, Class I vapor retarders are discouraged for use with non-vented claddings. Also recommended are drywall air sealing measures on the interior of the wall to minimize water vapor load delivered by bulk air leakage from the interior into the cavity.***

### Example Wall Assembly with Vapor Retarder

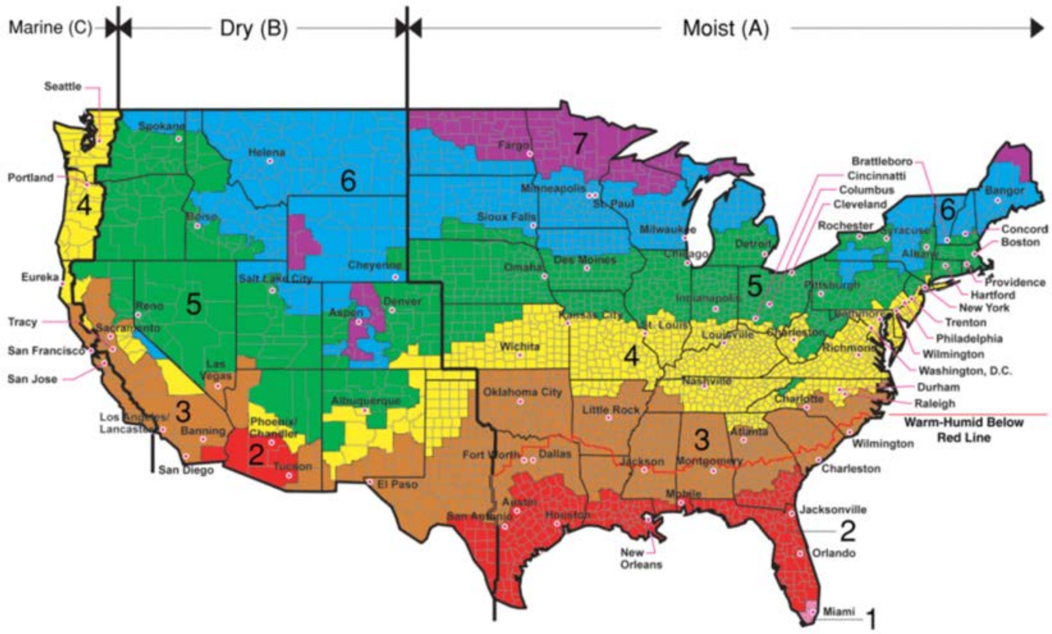



This figure shows an example wall assembly with vented cladding and a Class I or Class II interior vapor retarder.

- This wall allows drying to the outdoors. A Class II vapor retarder also allows drying to the indoors.
- A Class II vapor retarder is recommended in mixed-humid climate zones 4A and 3A above the warm-humid line and cold climates 4C and 5.

Example wall assembly:

1. Painted drywall (standard paint)
2. Vapor retarder (Class I or Class II)
3. Wall cavity insulation (permeable)
4. OSB structural sheathing
5. Vented cladding and WRB




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

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

**Figure 21. Climate Zone Map (Source: U.S. Department of Energy)**

**Table 18. Vented, Partially-Vented, and Non-Vented**

| Type | Air Flow Characteristics | Drying Characteristics | Cladding System Examples |
|---|---|---|---|
| Vented cladding | Unrestricted air flow behind cladding | Moisture accumulated in the wall sheathing can dry to the outside and water can flow down the drainage plane by gravity (unrestricted drainage plane) | Thin lap vinyl or aluminum siding<br>Siding installed over vertical furring<br>Cladding installed with a min 1/4 in. gap<br>Anchored stone and masonry veneer [A] |
| Partially-vented cladding | Partially restricted air flow behind cladding | Wall sheathing drying to the outside is partially restricted | Solid thick lap siding materials installed against WRB layer without furring and the bottom of each board overlaps the top of the board below such that part of the board is spaced away from the backing material (clapboard installation);<br>Solid wood siding products with flat installation have some ability to allow sheathing drying through vapor diffusion through the siding. |
| Non-vented cladding | Limited or no air flow behind cladding | Limited ability for the wall sheathing to dry to the outside;<br>Cladding may or may not have capacity to absorb and store water | Solid cladding installed without an air gap:<br>cementitious cladding (stucco), adhered masonry veneer, wood composite siding (flat installation), insulated vinyl siding |

[A] Including three-dimensional plastic mesh or plastic mat products.

**Table 19. Interior Vapor Retarders for 2x6 walls in Climate Zones 3-5**

| Climate zone | Cladding Type (refer to Table 18 for definition) | | | General Recommendations |
|---|---|---|---|---|
| | Vented Cladding | Partially-vented Lap Siding | Non-vented Cladding | |
| 3 | • **IRC:** Vapor retarder not required<br>• **Best Practice:** below warm-humid line (see Climate Zone map): interior vapor retarders should be avoided to allow drying to the indoors regardless of cladding type; above the warm humid line: interior vapor retarders are generally not necessary, but vented cladding is recommended.” | | | • As an added measure, a drywall air sealing package helps minimize air infiltration into the cavity and reduce moisture load from the entrained water vapor<br>• Retarders with a varying permeance (e.g., smart vapor retarders, Kraft paper) are always preferable for their ability to allow drying when needed<br>• Class I vapor retarders are generally discouraged and, if used, materials with low permeability should not be used exterior to framing |
| 4 (except 4C) | • **IRC:** Vapor retarder not required<br>• **Best Practice:** Class II or III | • **IRC:** Vapor retarder not required<br>• **Best Practice:** Class II or Class III | | |
| 4C | • **IRC:** Class I, II, or III<br>• **Best Practice:** Class II | • **IRC:** Class I or II<br>• **Best Practice:** Class II | | |
| 5 | • **IRC:** Class I, II, or III<br>• **Best Practice:** Class II | • **Best Practice:** Class II | | |

**VENTED**

**VENTED VINYL**

**NON VENTED**

# WATER RESISTIVE BARRIER

A Water Resistive Barrier (WRB) installed to the exterior of the sheathing is the same for both a 2x6 wall with studs spaced at 24 in. on center as for a traditional 2x4 wall with studs spaced at 16 in. on center. The primary purpose of a WRB, often referred to as the drainage plane, is to shed to the outside any bulk water that penetrated behind the cladding. The location of the drainage plane is between exterior wall sheathing and cladding in walls where the cladding is installed directly over the structural sheathing. Table 27 provides a list of materials commonly used in drainage plane applications including key design considerations. ***An air gap to the exterior surface of the water resistive barrier improves the effectiveness of the drainage plane by:***

- ***promoting drying;***
- ***eliminating capillary action; and***
- ***helping equalize pressure across the cladding surface.***

Refer to the Claddings section of the Guide for requirements and recommendations for specific wall material assemblies with regard to the combinations of water resistive barrier, air gap, and cladding. The WRB sheeting should be installed in a shingle fashion to ensure continuous shedding of water from top to bottom. When the WRB is installed to function also as an air barrier, all seams in the WRB should be taped; therefore, tape selection and installation is critical to the performance of the WRB as both a drainage plane and an air barrier.

**IRC Definition – WATER-RESISTIVE BARRIER.** A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

Table 20 lists a range of materials used in WRB installations including considerations for code compliance, vapor permeability, air barrier, moisture absorption, comparative performance, and field applications.

**Table 20. Typical Materials used in WRB Applications**

| Material | Compliance | Permeability, perm | Air barrier? | Water Absorptive? | Notes |
|---|---|---|---|---|---|
| No. 15 or No. 30 asphalt felt (asphalt saturated felt made from recycled fiber) | IRC, IBC ASTM D226 Type 1 felt | >1 perm (dry)<br>60 perm (wet)<br>(vapor permeability increases with RH) | No | Yes | No. 15 asphalt felt is the only product directly referenced in IRC/IBC as a WRB. No. 15 (30) is a designation, not a weight<br>No. 30 asphalt felt is a heavier product with increased absorption and tear resistance<br>Can support rot under high moisture conditions |
| Grade D building paper (asphalt saturated Kraft paper made with non-recycled wood fiber) | UU-B-790a Code Evaluation Reports (10 min to 60 or more min water resistance grades) | 5–30 perm (higher water resistant grades have lower vapor permeability; vapor permeability also increases with RH) | No | Yes | Lighter weight than asphalt felt<br>Lower water retention than asphalt felt<br>Easier to install at corners than asphalt felt<br>Grade D – water vapor permeable with minimum permeability of 4.5 perm (UU-B-790a)<br>Can support rot under high moisture conditions |
| Plastic housewrap (polyolefin) (perforated or non-perforated) | Code Evaluation Reports | 5– >50 perm (typically not RH dependent, except 'smart' housewrap products) | Perforated - No Non-perforated – Partial, if top and bottom and all seams are taped in accordance with manufacturer's instructions | No | Plastic housewraps can be non-woven non-perforated or woven perforated<br>In laboratory testing, non-woven membrane has a higher water holdout and air infiltration resistance properties<br>In the field, housewrap membrane is typically punctured by cladding fasteners<br>There is limited data available from independent studies on in-service walls to enable recommending housewraps with a specific level of vapor permeability within the range of the commercially available products |
| Plastic housewrap with built-in drainage (polyolefin) | Code Evaluation Reports | 5-60 perm (typically not RH dependent, except 'smart' housewrap products) | Non-perforated – Partial, if top and bottom and all seams are taped in accordance with manufacturer's instructions | No | This product category is similar to standard housewrap except the material includes a built-in mechanism (e.g., vertical groves, spacers) for improved water drainage by creating air space behind the cladding. This housewrap is intended to combine the functionality of standard housewrap and furring |
| Liquid-applied membrane | Code Evaluation Reports | 3-25 perm (not RH dependent) | Yes | No | Permeability varies with number of coats (i.e., thickness) and by proprietary product |
| Integral sheathing membrane with taped joints | Code Evaluation Reports | Varies by specific product | Yes, if top & bottom & all seams are taped in accordance with manufacturer's instructions | No Varies by specific product | Refer to the product manufacturer for information on the specific product |
| Rigid foam with taped joints | Not addressed in this Section of the Guide | | | | |
| Mutli-layered WRB systems | Two layers of the same or different membrane is recommended for specific claddings. See Claddings section for more information. | | | | |

# CLADDINGS

### DRAINAGE PLANE

Claddings are integrated with the drainage plane to complete an effective bulk water resistant system (Figure 22). The choice and detailing of the cladding impacts the design of the drainage plane and selection of the interior vapor retarder (also see Vapor Retarder Section). The stud spacing impacts cladding attachment requirements and in some cases the selection of the cladding products. Tables 21-26 provide guidance for six typical cladding materials.

### FRAMING SPACING

Many siding products may not have a published detail for installation using framing spaced at more than 16 in. on center. With the growing application of advanced wall systems and with framing at 24 in. on center, standard installation guidelines for vinyl siding have been developed for installation directly to wood sheathing. Table 27 outlines the fastener type and length for various vinyl siding lap widths.

### ATTACHMENT

Claddings shall be attached to the wall using fasteners in accordance with manufacturers' instructions for the cladding and the applicable building code requirements in the IRC. Where furring strips (strapping) are used, each furring strip shall be securely fastened to the studs with nails or screws (refer to Table 28). Only vertical furring installation is addressed by this Guide. Horizontal furring creates potential for water trapping joints. For compliance with the requirements for furring strip fastener penetration into framing, the thickness of the WSP sheathing can be included in the penetration depth. For compliance with the requirements for siding fastener penetration into framing, the thickness of the WSP sheathing or furring plus WSP sheathing (whichever applicable) can be included in the penetration depth.

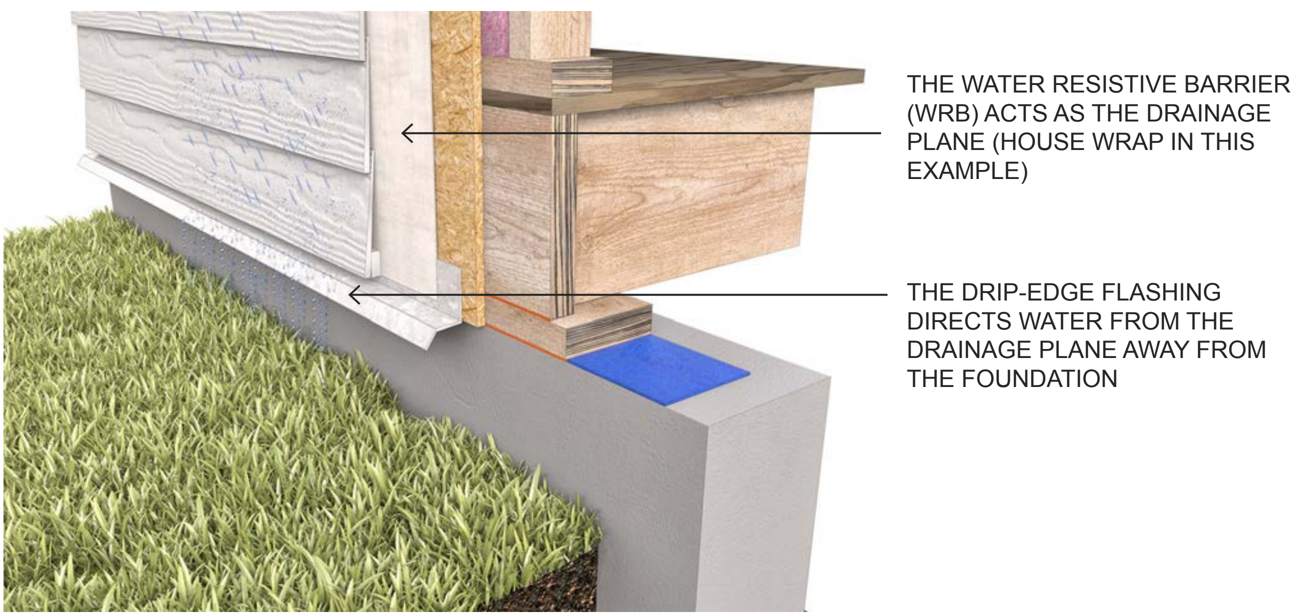



**Figure 22. Example Drainage Plan**

**Table 21. Vinyl Siding Installation**

| VINYL SIDING INSTALLATION | | |
|---|---|---|
| **Air Gap** | Integral with cladding (i.e., vented cladding). | |
| **WRB** | Any WRB material in Table 20 can be used in a single layer application. | |
| **Attachment** | **16 in. on center studs** | **24 in. on center studs** |
| | Most standard vinyl siding products are rated for 16 in. on center applications and installed directly over exterior sheathing with fasteners (nails or staples) required to penetrate framing.<br><br>Standard vinyl siding may be attached to WSP sheathing only (framing penetration not required) in accordance with Table 27. | Options:<br>1. Vinyl siding rated for 24 in. on center applications with fasteners penetrating framing (typically thicker plastic material used to fabricate siding).<br>2. Standard vinyl siding attached to WSP sheathing only (framing penetration not required) in accordance with Table 27.<br>Manufacturers' recommendations for specific product (e.g., attached to studs at 24 in. on center and one fastener into WSP between studs). |
| **Code Compliance** | 2012 IRC R703.4 and R703.11, ASTM D 3679.<br>Install siding in accordance with Code Evaluation Report and/or Manufacturers Installation Instructions. | |
| **Wind Resistance** | Verify wind load compliance in accordance with manufacturer's installation instructions based on siding rating and fastening schedule. Vinyl siding should not be attached to furring strips unless the space between the furring strip is filled with a rigid material. | |

**Table 22. Fiber Cement Lap Siding**

| FIBER CEMENT LAP SIDING | | |
|---|---|---|
| **Air Gap** | Where installed directly over exterior WSP sheathing/WRB, compartmentalized air gap is created by lap siding overlap and bound by the siding top edge in contact with sheathing. This installation provides some venting but does not provide direct drainage.<br>For a continuous air gap, siding can be installed over furring strips or over plastic housewrap with built-in drainage. | |
| **WRB** | Any WRB material in Table 20 can be used in a single layer application.<br>Siding installation over furring or housewrap with built-in drainage can be used to improve drainage and minimize moisture drive through the WRB at the points of contact with siding. | |
| **Attachment** | A wide range of product installation options is offered by siding manufacturers for 16 and 24 in. on center framing. The following parameters influence the wind rating for a given installation: siding width, fastener type and size, fastening method (blind vs. face-nailed), framing spacing, and framing wood species. Siding manufacturer's Evaluation Report should be followed for the specific installation rating. Examples for 16 and 24 in. on center installations are provided below for one specific lap siding product 9-1/4 in. wide 5/16 in. thick attached with 6d box nails face-nailed through overlap for buildings up to 40 feet in height in Wind Exposure C (wind speed and exposure are based on 2012 IRC). | |
| | **16 in. on center studs** | **24 in. on center studs** |
| | Maximum basic wind speed of 114 mph (positive or negative pressures). | Maximum basic wind speed of 93 mph (positive or negative pressures). |
| **Code Compliance** | 2012 IRC R703.4 and R703.10.2, ASTM C 1186, Type A, Minimum Grade II. | |
| **Wind Resistance** | Verify wind load compliance in accordance with manufacturer's installation instructions based on siding rating and fastening schedule. Each product rating is specific to that manufacturer and is not interchangeable with other products. | |

**Table 23. Cedar Plank Siding (Horizontal): Clapboard or Flat Installation**

| CEDAR PLANK SIDING (HORIZONTAL): CLAPBOARD OR FLAT INSTALLATION | | |
|---|---|---|
| **Air Gap** | Clapboard installation: where installed directly over exterior WSP sheathing/WRB, compartmentalized air gap is created by lap siding overlap and bound by the siding top edge in contact with sheathing. This installation directly over standard WRB provides some venting but does not provide direct drainage.<br>Flat installation: where installed directly over exterior WSP sheathing/WRB, no air gap is present. Drying occurs to the outside through the siding. Solid wood products with minimum thickness have good drying potential through vapor diffusion.<br>It is recommended by this Guide that cedar siding be installed over furring strips or housewrap with built-in drainage. | |
| **WRB** | Any WRB material in Table 20 can be used in a single layer application.<br>Siding installation over furring or housewrap with built-in drainage can be used to improve drainage, minimize moisture drive through the WRB at the points of contact with siding, and facilitate drying of siding.<br>In addition to the benefit of venting, furring strips reduce the potential for surfactants found in cedar siding to affect the performance of the WRB material.<br>Where installed in contact with plastic housewrap, back-primed cedar siding is recommended to minimize surfactants effect. | |
| **Attachment** | **16 in. on center studs** | **24 in. on center studs** |
| | Cedar plank siding can be attached at 16 or 24 in. on center either over WSP sheathing/WRB or over furring strips. Where installed over WSP sheathing/WRB, the minimum penetration into solid wood material shall be 1-1/4 in. (WRCLA). Where installed over furring strips, the minimum penetration into solid wood material (furring, WSP, and framing) shall be 2-1/2 in. for nails and 2 in. for staples (IRC). One fastener per bearing is required for planks up to 6 in. wide and two fasteners are required for wider planks. Where installed over furring strips, the minimum siding thickness is 1/2 in. (IBC). | |
| **Code Compliance** | 2012 IRC R703.3.2, IRC R703.4, Western Red Cedar Lumber Association (WRCLA) Installation Guidelines, IBC 1405.2 | |
| **Wind Resistance** | Verify wind load compliance in accordance with manufacturer's installation instructions based on siding thickness and fastening schedule. The code compliance is achieved through the prescriptive IRC code provisions for wind speeds below 110 mph (2012 IRC). For higher wind speeds, engineered design is required. | |

**Table 24. Anchored Veneer**

| ANCHORED VENEER | | |
|---|---|---|
| **Air Gap** | One in. minimum air gap. | |
| **WRB** | Any WRB material in Table 20 can be used in a single layer application | |
| **Attachment** | **16 in. on center studs** | **24 in. on center studs** |
| | Metals ties spaced 16 in. horizontally and 24 in. vertically and attached to framing with one 8d common nail.<br>In SDC D0 and higher (SDC C for townhouses) or where wind pressure exceeds 30 psf, vertical spacing is reduced to 18 in. | Metal ties spaced 24 in. horizontally and 16 in. vertically and attached to framing with one 8d common nail.<br>In SDC D0 and higher (SDC C for townhouses) or where wind pressure exceeds 30 psf, vertical spacing is reduced to 12 in. |
| **Code Compliance** | 2012 IRC R703.4 and R703.7 | |
| **Wind Resistance** | The code compliance is achieved through the prescriptive IRC code provisions for wind speeds below 110 mph (2012 IRC). For higher wind speeds, engineered design is required. | |

**Table 25. Cement Stucco (Exterior Plaster)**

<table>
<tr><th colspan="3">CEMENT STUCCO (EXTERIOR PLASTER)</th></tr>
<tr><td>Air Gap</td><td colspan="2">Stucco is considered Non-vented Cladding for use with Table 19 unless stucco is fully uncoupled from the WRB drainage plane by a vented air gap.</td></tr>
<tr><td>WRB</td><td colspan="2">Two layers of Grade D paper or equivalent.<br>Installation with air gap: single layer of 60-min. Grade D paper or equivalent.<br>Other approved equivalent options.</td></tr>
<tr><td rowspan="2">Attachment</td><td>16 in. on center studs</td><td>24 in. on center studs</td></tr>
<tr><td>All metal plaster base products (expanded metal lath or wire lath) are rated for use with maximum studs spacing at 16 in. on center. Metal plaster base attached to studs through WSP sheathing with approved nails or staples spaced a max of 6 in. on center along each stud. Fasteners must penetrate the framing member by a minimum of 3/4 in. All horizontal joints are recommended to be blocked for edge support.</td><td>Many metal plaster base products (expanded metal lath or wire lath) are rated for use over WSP sheathing with supporting studs spaced at 24 in. on center (refer to ASTM C1063 or lath manufacturer’s specifications). Metal plaster base attached to studs through WSP sheathing with approved nails or staples in accordance with one of the following:<br>• 6 in. on center spacing and 1-1/8 in. min. penetration into the framing.<br>• 4 in. on center spacing and 3/4 in. min. penetration into the framing.<br>All horizontal joints are recommended to be blocked for edge support. WSP manufacturers also recommend increasing the thickness and/or span rating of WSP sheathing for use as stucco substrate with 24 in. on center framing for sufficient supporting stiffness.</td></tr>
<tr><td>Code Compliance</td><td colspan="2">2012 IRC R703.4 and R703.6<br>ASTM C1063 Sections 7.10.1.2, 7.10.2, Table 3</td></tr>
<tr><td>Wind Resistance</td><td colspan="2">The code compliance is achieved through the prescriptive IRC code provisions for wind speeds below 110 mph (2012 IRC). For higher wind speeds, engineered design is required.</td></tr>
</table>

**Table 26. Engineered Wood Siding (Lap, Horizontal)**

| ENGINEERED WOOD SIDING[A] (LAP, HORIZONTAL) | | |
|---|---|---|
| **Air Gap** | Standard installation (flat installation) recommended by siding manufacturers provides no air gap. Installation over furring or housewrap with built-in drainage promotes drying and drainage. Installation in a clapboard fashion promotes drying by providing partial venting between courses. | |
| **WRB** | For flat installations, follow siding manufacturer's instructions for selection of WRB. Where such recommendations are not available, it is recommended to use a more permeable WRB product to allow drying to the inside.<br><br>Where furring is used, any WRB material in Table 20 can be used in a single layer application. Note that permeability of various types of engineered wood siding can vary and is always less than solid wood siding. | |
| **Attachment** | **16 in. on center studs** | **24 in. on center studs** |
| | Standard products rated for 16 in. on center installation. | Manufacturers provide a thicker siding product (e.g., 7/16 vs. 3/8) or permit the use of alternate fastening schedules (e.g., 24 in. on center nailing with an additional ring-shank nail into WSP sheathing between studs). |
| **Code Compliance** | CPA/ANSI A135.6, 2012 IRC Section 703.4 | |
| **Wind Resistance** | Verify wind load compliance in accordance with manufacturer's installation instructions. | |

[A] For walls with wet-blown insulation, check with the siding manufacturer for siding usage and installation.

**Table 27. Vinyl Siding Attachment to 7/16 Wood Structural Panel Sheathing – Maximum Fastener Spacing (in.)**

| Vinyl Siding Width (Exposure), in. | Fastener Type | | | | |
|---|---|---|---|---|---|
| | Ring shank roofing nail (0.120" min. dia.) OR #6 screw (0.138" min. dia.) | Ring shank nail (0.148" min. dia.) | #8 screw (0.164" min. dia.) | Smooth shank roofing nail (0.120" min. dia.) | Staples |
| 7 | 20 | 25 | 27 | 5.0 | Per vinyl siding manu-facturer's instructions |
| 8 | 18 | 22 | 24 | 4.5 | |
| 9 | 16 | 20 | 21 | 4.0 | |
| 10 | 14 | 18 | 19 | 3.5 | |
| 12 | 12 | 15 | 16 | 3.0 | |

**Table 28. Attachment Schedule for Vertical Furring Strips (Strapping) to Studs – Vertical Spacing of Fasteners (in.) [A B]**

| Furring fastener | Min. penetration of furring fastener into WSP sheathing and framing | 16 in. On Center Stud Spacing (Furring strip attached to each stud) | | 24 in. On Center Stud Spacing (Furring strip attached to each stud) | |
|---|---|---|---|---|---|
| | | 1x3 Wood Furring | 1x4 Wood Furring | 1x3 or 1x4 Wood Furring | 2x3 Wood Furring |
| Smooth-shank nail with min D=0.131" | **1-1/4"** | **12"** | **12"** | **8"** | **8"** |
| #10 Wood Screw | **1.0"** | **16"** | **24"** | **16"** | **24"** |

[A] Wood furring shall have minimum specific gravity of 0.42.

[B] Siding fastener penetration shall meet the minimum requirements for the siding product. Where the minimum required penetration exceeds the combined thickness of the furring and the WSP sheathing, the fastener shall penetrate the stud or a thicker furring strip (e.g., 2x3) shall be used.

# WINDOW AND DOOR INSTALLATION AND FLASHING

Window and door installation for a 2x6 wall with studs spaced at 24 or 16 in. on center is similar to traditional 2x4 wall with studs spaced at 16 in. on center. Therefore, installation of doors and windows in 2x6 walls is not addressed in depth in this Guide. Windows are typically installed with flanges at the exterior structural sheathing and integrated with the WRB using flashing to provide a continuous drainage surface. The added wall depth requires interior extended jambs or drywall returns.

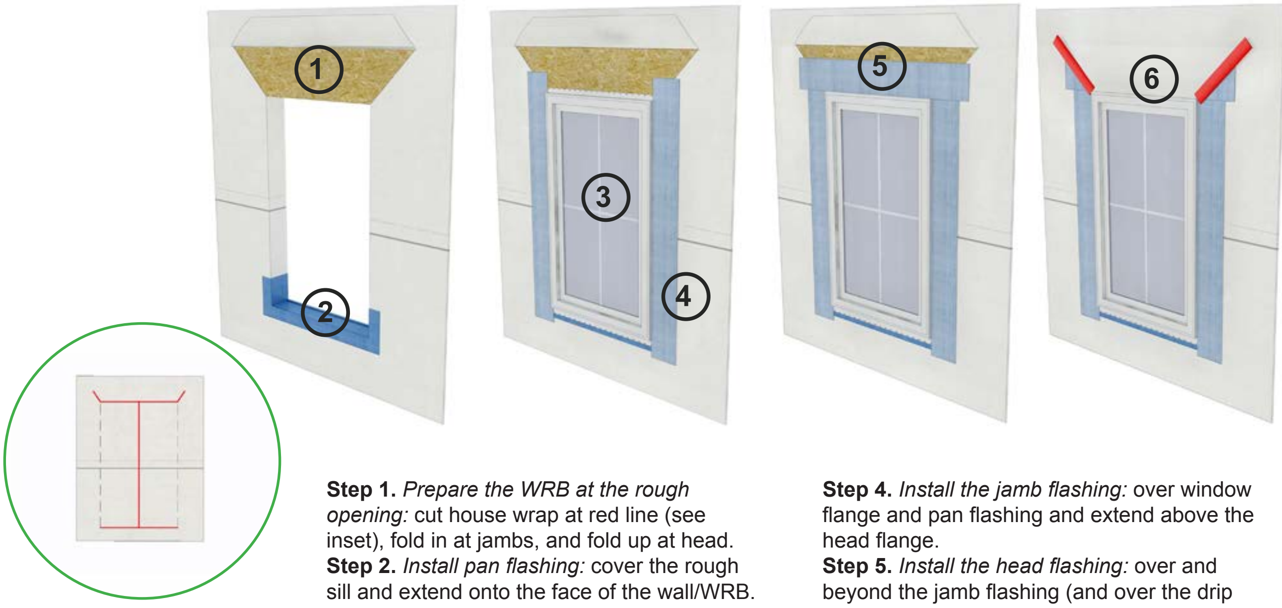
Flashing installation for a 2x6 wall with studs spaced at 24 or 16 in. on center is the same as for a traditional 2x4 wall with studs spaced at 16 in. on center. Flashing is an integral part of a wall assembly that prevents bulk water intrusion at junctions of different wall assembly elements. Flashing approaches vary with the WRB type and in general are not directly impacted by the selection of the vapor retarder and air sealing strategy.

There are two key principles for effective flashing at windows and doors to allow water to drain down the face of the wall and away from the building:

- **Integrate** flashing with the **water-resistive barrier** (WRB), e.g., house wrap.
- Install membranes shingle-fashion where the top layer of the WRB or flashing laps over the bottom layer to prevent water draining behind the bottom layer.

Flashing detailing depends on the selection of (1) window type (flanged or non-flanged) and door type (with or without integral molding); and (2) window/door installation sequence (windows/doors installed before or after the WRB). The following graphics show the essential steps for installing window or door flashing (Figure 23); these align with installation guidelines from most product manufacturers.

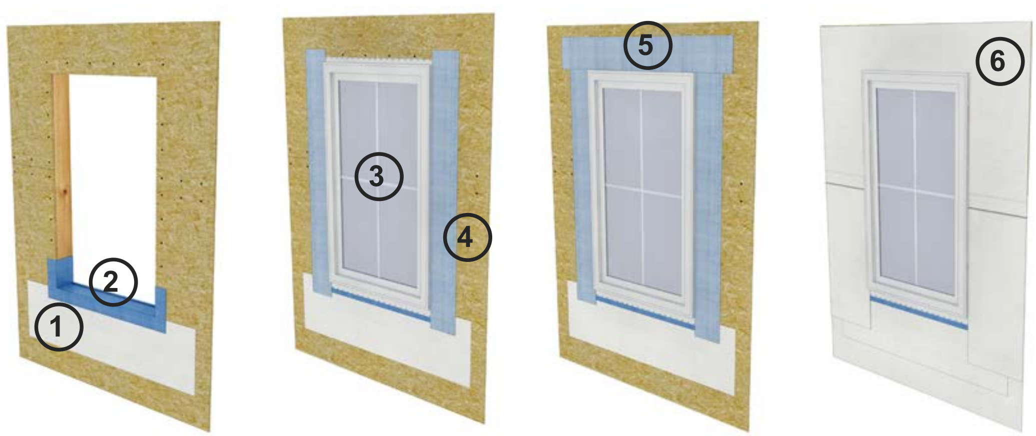
## EXAMPLE FLASHING STEPS FOR A FLANGED WINDOW INSTALLED AFTER HOUSE WRAP




**Step 1.** *Prepare the WRB at the rough opening:* cut house wrap at red line (see inset), fold in at jambs, and fold up at head.
**Step 2.** *Install pan flashing:* cover the rough sill and extend onto the face of the wall/WRB.
**Step 3.** *Install the window:* according to manufacturer's instructions.

**Step 4.** *Install the jamb flashing:* over window flange and pan flashing and extend above the head flange.
**Step 5.** *Install the head flashing:* over and beyond the jamb flashing (and over the drip cap if installed).
**Step 6.** *Integrate the WRB:* fold down the house wrap flap and tape diagonal seams with construction tape.

## EXAMPLE FLASHING STEPS FOR A FLANGED WINDOW INSTALLED BEFORE HOUSE WRAP




**Step 1:** *Prepare the WRB at the rough opening:* install a small section of house wrap below the sill (referred to as an "apron"); alternatively, install self-adhesive pan flashing with split backing (where the release paper backing can be removed incrementally) to seal to the house wrap later.
**Step 2:** *Install pan flashing:* cover the rough sill and extend onto the face of the wall/WRB.
**Step 3:** *Install the window:* according to manufacturer instructions.

**Step 4:** *Install the jamb flashing:* over window flange and pan flashing and extend above the head flange.
**Step 5:** *Install the head flashing:* over and beyond the jamb flashing (and over the window drip cap if installed).
**Step 6:** *Integrate the WRB:* Install house wrap shingle-fashion, integrated with the apron, and seal house wrap at jambs and head using sealant (beneath the house wrap) or construction tape.

## EXAMPLE FLASHING STEPS FOR AN ENTRY DOOR WITH INTEGRAL BRICK MOLD INSTALLED AFTER HOUSE WRAP


**Step 1.** *Prepare the WRB at the rough opening:* cut and fold house wrap (similar to figure above for window installed after house wrap).
**Step 2.** *Install pan flashing:* for a slab or foundation wall application, align the front edge for a continuous slab or foundation wall application, or fold down for a step down slab; it is important to integrate a back dam with the finish flooring/trim.
**Step 3.** *Install the door:* where sealant is used under the door threshold, ensure that water is allowed to drain out of the pan flashing. For this example, apply sealant at the WRB/brick mold interface at the top and sides (shown in red). Install a drip cap of metal, plastic, or other approved material (shown as green) above the brick mold (as required by the door manufacturer, particularly where not protected by a porch or overhang) in a bead of sealant and secure to the wall.

**Step 4.** For this example, the sealant acts as the jamb flashing. After installing the door, apply additional sealant where the brick mold meets the house wrap.
**Step 5.** *Install the head flashing:* over the vertical leg of the drip cap.
**Step 6.** *Integrate the WRB:* fold down the house wrap flap and tape diagonal seams with construction tape.

**Figure 23. Window Flashing Examples**

# ENERGY EFFICIENT TRUSSES

High-heel or cantilever trusses reduce thermal bridging (cold joint) at the roof-to-wall interface typical for conventional roof framing. The added height of a high-heel truss or cantilever truss allows for additional attic insulation installed directly above the wall top plate. Measures against wind-washing and attic ventilation measures are implemented for the energy truss in the same manner as for conventional low-heel trusses. One significant difference is the recent code requirement for lateral bracing at the eave joint for all trusses that exceed 9-1/4 in. between the wall top plate and the underside of the roof sheathing (measured in the plane of the exterior face of the stud). The lateral bracing can be provided with solid blocking, blocking panels, or soffit blocking between each truss (at braced wall panels). The IRC provides several blocking options for high-heel and cantilever trusses. However, a simplified method to add lateral bracing has been tested demonstrating multiple benefits.

Figure 24 depicts two alternative methods for using exterior WSP sheathing in lieu of blocking to provide lateral stability for high-heel trusses. In both methods, the WSP is used as a backer for installing attic insulation and air sealing at the top plate. While neither method is explicitly documented in the building code at this time, they can easily be engineered to meet building code requirements.

The first method uses a WSP strip nailed to the truss heel and the top plate of the supporting wall. The nailing schedule is 4 in. on center into truss (a minimum of 3-8d common (D=0.131") or 4-8d box (D=0.113") nails) and 6 in. on center into the top plate (same nails as used for roof truss). This method should be used for house configurations and locations within the scope of the IRC prescriptive provisions.

The second method uses oversized, continuous WSP sheathing extending from the supporting wall below onto to the heel of the truss. The continuous WSP that connects the roof to the supporting wall also provides an uplift load path and can replace metal hardware for some roof configurations in low wind-hazard zones. The supplier of the oversized OSB panels should be contacted for nailing schedule and wall anchorage requirements for use with its panels in combined uplift and shear applications. In many applications, 5-8d common nails for 15-1/4 in. heel and 7-8d common nails for 24 in. heel are sufficient for connecting OSB sheathing to the truss; sheathing nails at the top plate are spaced at 4 in. on center.

**METHOD 1**

A WSP is attached from the second (upper) wall top plate through the raised heel truss member to the truss top cord.

**METHOD 2**

An oversized WSP is attached from the wall bottom plate up through the raised heel truss member to the truss top cord.

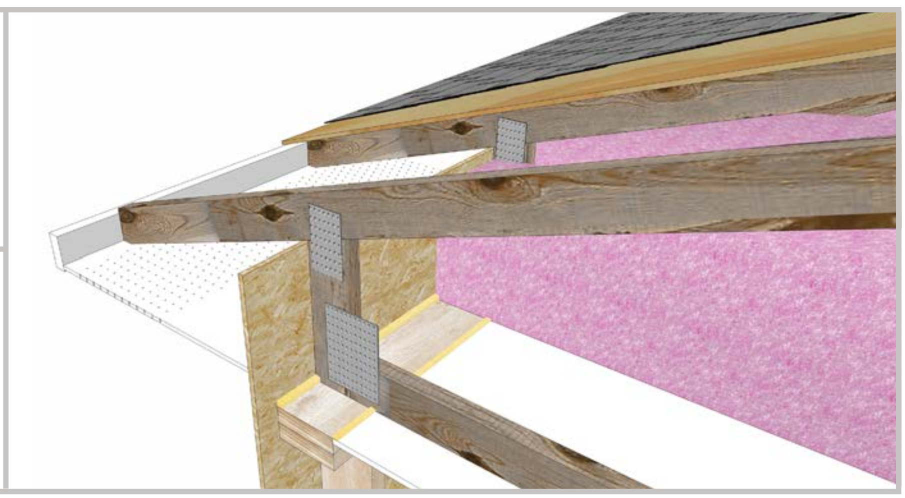


**Figure 24. High Heel Truss**

DOE/EE-1673-1