DrJ Research Report

DRR 1506-04

Attachment of Exterior Wall Coverings through Extruded Polystyrene (XPS) to Wood or Steel Wall Framing

Extruded Polystyrene Producing FSC Members

Product:
Attachment of exterior wall coverings through Extruded Polystyrene (XPS) Foam Plastic Insulating Sheathing (FPIS) to wood or steel wall framing

Issue Date:
June 24, 2015

Revision Date:
July 1, 2020
DIVISION: 07 00 00 - THERMAL AND MOISTURE PROTECTION

SECTION: 07 21 00 - Thermal Insulation

SECTION: 07 40 00 - Roofing and Siding Panels

SECTION: 07 46 00 - Siding

1 PRODUCT EVALUATED¹

1.1 Attachment of exterior wall coverings through Extruded Polystyrene (XPS) Foam Plastic Insulating Sheathing (FPIS) to wood or steel wall framing

1.1.1 DuPont de Nemours, Inc.

1.1.2 Kingspan Insulation, LLC

2 APPLICABLE CODES AND STANDARDS²,³

2.1 Codes

2.1.1 IBC—12, 15, 18: International Building Code®

2.1.2 IRC—12, 15, 18: International Residential Code®

2.1.3 IECC—12, 15, 18: International Energy Conservation Code®

2.2 Standards and Referenced Documents

2.2.1 AISI S100: North American Specification for the Design of Cold-formed Steel Structural Members

2.2.2 ANSI/AWC NDS: National Design Specification (NDS) for Wood Construction

2.2.3 ASCE/SEI 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures

2.2.4 SBCA ANSI/FS 100: Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies

¹ Building codes require data from valid research reports be obtained from approved sources. Work of licensed registered design professionals (RDPs) meets the code requirements for approval by the building official.

Building official approval of a licensed RDP is performed by verifying the RDP and/or their business entity complies with all professional engineering laws of the relevant jurisdiction. Therefore, the work of licensed RDPs is accepted by building officials, except when plan (i.e. peer) review finds an error with respect to a specific section of the code. Where this DRR is not approved, the building official responds in writing stating the reasons for disapproval.

For more information on any of these topics or our mission, product evaluation policies, product approval process, and engineering law, visit drjengineering.org or call us at 608-310-6748.

² Unless otherwise noted, all references in this DRR are from the 2018 version of the codes and the standards referenced therein (e.g., ASCE 7, NDS, ASTM). This material, design, or method of construction also complies with the 2000-2015 versions of the referenced codes and the standards referenced therein.

³ All terms defined in the applicable building codes are italicized.
3 EVALUATION SCOPE

3.1 This research report examines the attachment of exterior wall coverings through XPS, with thickness up to 4", to wood or cold-formed steel wall studs.

3.2 This research report also provides a step-by-step approach for the design process of attaching exterior wall coverings through XPS to wood or steel wall framing.

3.3 This evaluation and design methodology considers only the weight of the exterior covering on fasteners cantilevered through the XPS and into the stud.

3.4 Wind pressure resistance of the exterior covering is outside the scope of this research report. Consult the exterior covering manufacturer’s installation instructions for information regarding the allowable design wind pressure for a given product in accordance with SBCA ANSI/FS 100.

3.4.1 The intent of this research report is not to reduce minimum fastener sizes, penetrations, and spacings required to resist wind loads. Where fastener requirements for wind or cladding weight are more stringent, they shall control the design.

3.5 Attachment of window flanges over XPS is outside the scope of this research report.

3.6 Any code compliance issues not specifically addressed in this section are outside the scope of this DRR.

3.7 Any engineering evaluation conducted for this DRR was performed on the dates provided in this DRR and within DrJ's professional scope of work.

4 PRODUCT DESCRIPTION AND MATERIALS

4.1 XPS products used in accordance with this research report shall comply with the following material standards:

4.1.1 Extruded polystyrene (XPS) manufactured in compliance with ASTM C578

4.2 XPS products used in accordance with this research report shall have a minimum compressive strength of 15 psi.

4.3 Where wind pressure resistance is required, XPS products used in accordance with this research report shall comply with SBCA ANSI/FS 100.

4.4 XPS products are produced under proprietary manufacturing processes and are formed into rigid insulation panels.

4.5 XPS products are typically available in the following sizes:

4.5.1 Thicknesses range from ½" to 6".

4.5.2 The standard product width is 48".

4.5.3 Standard lengths include 96", 108", and 120".

4.6 Consult the manufacturer for the availability of a given product with non-standard width or length.

4.7 The following XPS products meet the requirements of Section 4.1 and 4.2:

4.7.1 DuPont de Nemours, Inc. – Styrofoam™

4.7.2 Kingspan Insulation, LLC – GreenGuard® XPS Insulation Board CM, GreenGuard® XPS Insulation Board SB, GreenGuard® XPS Insulation Board DC, GreenGuard® XPS Insulation Board SL, GreenGuard® SLX Sheathing, GreenGuard® Plygood® Ultra Sheathing, and GreenGuard® R-5 XPS Insulation

5 APPLICATIONS

5.1 Design Procedure

5.1.1 Determine an appropriate cladding attachment requirement in accordance with Section 5.2 through 5.4.

5.2 Select one of the following methods of cladding attachment:

5.2.1 Direct attachment of cladding through XPS to wall framing, Figure 1.
5.2.2 Furring attachment through XPS to wall framing, Figure 2, whereby cladding is attached to furring in accordance with the applicable building code and the cladding manufacturer’s installation instructions.

5.3 From Table 1 for “direct attachment” method or Table 2 for “furring attachment” method, determine the maximum allowable XPS thickness based on a selected minimum fastener size, maximum fastener spacing, and the cladding system weight.

5.3.1 To determine cladding system weight, add the weight of all materials on the exterior side of the foam sheathing (see ‘a’ in Figure 1 and ‘a’ and ‘b’ in Figure 2).

5.3.2 Use actual weights for the materials installed. Actual cladding weights of materials can be obtained from the cladding manufacturer’s material specifications. Other typical weights of building materials can be found in the Commentary to ASCE 7-10.
**Table 1. Siding Min. Fastening for Direct Cladding Attachment over FPIS to Support Cladding Weight**

<table>
<thead>
<tr>
<th>Cladding Fastener Through FPIS into:</th>
<th>Siding Fastener – Type &amp; Minimum Size</th>
<th>Maximum Thickness of FPIS (in)</th>
<th>16&quot; o.c. Fastener Horizontal Spacing</th>
<th>24&quot; o.c. Fastener Horizontal Spacing</th>
<th>Maximum Cladding Weight (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Framing (minimum 1¼&quot; penetration)</td>
<td>0.113&quot; diameter nail</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>DR</td>
<td>2</td>
<td>0.75</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>1</td>
<td>DR</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>0.5</td>
<td>DR</td>
<td>2</td>
<td>DR</td>
</tr>
<tr>
<td>0.120&quot; diameter nail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>1.5</td>
<td>0.5</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>1</td>
<td>DR</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>0.5</td>
<td>DR</td>
<td>2</td>
<td>DR</td>
</tr>
<tr>
<td>0.131&quot; diameter nail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0.75</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>1.5</td>
<td>0.5</td>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>0.75</td>
<td>DR</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>0.162&quot; diameter nail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>4</td>
<td>1.5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>0.75</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Steel Framing (minimum penetration of steel thickness + 3 threads)</td>
<td>#8 screw into 33 mil steel or thicker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>3</td>
<td>1.5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>2</td>
<td>0.5</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>1.5</td>
<td>DR</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>#10 screw into 33 mil steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>DR</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>#10 screw into 43 mil steel or thicker</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>3</td>
<td>1.5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

St: 1 in = 25.4 mm, 1 psf = 0.0479 kN/m²

1. Tabulated requirements are based on wood framing of Spruce-Pine-Fir (SPF) or any wood species with a specific gravity of 0.42 or greater in accordance with NDS and minimum 33 ksi steel for 33 mil and 43 mil steel and 50 ksi steel for 54 mil steel or thicker.
2. Cladding weight shall include all materials supported by the fasteners on the exterior side of the foam sheathing (e.g., wood structural panel sheathing may be installed between the cladding material and the foam sheathing). In such cases, both the cladding and the WSP sheathing weight must be included in the calculation for the cladding weight.
3. Examples of cladding included in each weight category: 3 psf – vinyl siding, 11 psf – fiber cement siding, 25 psf – masonry or cultured stone. Examples are not inclusive.
4. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths. Screws shall comply with ASTM C1513.
5. Self-drilling tapping screw fasteners for connection of siding to steel framing shall comply with the requirements of AISI S200. Other approved fasteners of equivalent or greater diameter and bending strength shall be permitted.
6. For cladding system weights exceeding 25 psf with any thickness of foam sheathing, a design professional should be consulted.
7. Table 1 solutions are limited to 4" maximum thickness of foam sheathing. Design is required for thicknesses of foam sheathing greater than 4".
8. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578.
9. Metal lath shall be minimum 2.5 lbs./yd.² diamond mesh in accordance with ASTM C847. Metal lath lock washers on fasteners are highly recommended.
10. Vertical spacing of fasteners in metal lath shall not exceed 7" o.c., in accordance with ASTM C1063 and the Masonry Veneer Manufacturer Association (MVMA) Installation Guide.
11. Where adhered masonry is used, it shall be installed in accordance with the MVMA Installation Guide.
12. Linear interpolation between cladding weight categories is not permissible.
13. DR = Design Required
### Table 2. Furrring Min. Fastening for Application Over FPIS to Support Cladding Weight & Resist Wind Pressure

<table>
<thead>
<tr>
<th>Furring Material</th>
<th>Framing Member</th>
<th>Fastener Type &amp; Minimum Size</th>
<th>Minimum Penetration into Wall Framing</th>
<th>Fastener Spacing in Furring (in)</th>
<th>Maximum Thickness of FPIS (in)</th>
<th>Allowable Wind Pressure Resistance of Furring Attachment (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum 1x3 Wood Furring</td>
<td>Minimum 2x Wood Stud</td>
<td>Nail (0.120&quot; shank; 0.271&quot; head)</td>
<td>1 1/4&quot;</td>
<td>8 2</td>
<td>1.5 0.5 2 1 DR</td>
</tr>
<tr>
<td></td>
<td>Minimum 33 mil Steel Stud</td>
<td>33 mil Steel Hat Stud</td>
<td>Nail (0.131&quot; shank; 0.281&quot; head)</td>
<td>1 1/4&quot;</td>
<td>8 4</td>
<td>2 1.5 4 1.5 DR</td>
</tr>
<tr>
<td></td>
<td>Minimum 33mil Steel Hat Channel or Minimum 1x3 Wood Furring</td>
<td>43 mil or thicker Steel Stud</td>
<td>0.162&quot; diameter nail</td>
<td>1 1/4&quot;</td>
<td>8 4</td>
<td>4 1.5 4 2 0.75 DR</td>
</tr>
<tr>
<td></td>
<td>Minimum 33mil Steel Hat Channel or Minimum 1x3 Wood Furring</td>
<td>Minimum 1x3 Wood Furring</td>
<td>#10 wood screw</td>
<td>1&quot;</td>
<td>12 4</td>
<td>2 0.75 4 1.5 DR</td>
</tr>
<tr>
<td></td>
<td>Maximum Thickness of FPIS</td>
<td>43 mil or thicker Steel Stud</td>
<td>1/4&quot; lag screw</td>
<td>1 1/2&quot;</td>
<td>12 4</td>
<td>3 1 4 2 0.5 DR</td>
</tr>
<tr>
<td></td>
<td>Maximum Thickness of FPIS</td>
<td>Minimum 1x3 Wood Furring</td>
<td>#8 screw (0.285&quot; head)</td>
<td>Steel thickness +3 threads</td>
<td>12 3</td>
<td>1.5 3 0.5 DR</td>
</tr>
<tr>
<td></td>
<td>Maximum Thickness of FPIS</td>
<td>Minimum 1x3 Wood Furring</td>
<td>#10 screw (0.333&quot; head)</td>
<td>Steel thickness +3 threads</td>
<td>12 4</td>
<td>2 DR DR</td>
</tr>
<tr>
<td></td>
<td>Maximum Thickness of FPIS</td>
<td>Minimum 1x3 Wood Furring</td>
<td>#8 screw (0.285&quot; head)</td>
<td>Steel thickness +3 threads</td>
<td>12 3</td>
<td>1.5 DR</td>
</tr>
<tr>
<td></td>
<td>Maximum Thickness of FPIS</td>
<td>Minimum 1x3 Wood Furring</td>
<td>#10 screw (0.333&quot; head)</td>
<td>Steel thickness +3 threads</td>
<td>12 4</td>
<td>3 1.5 4 3 DR</td>
</tr>
</tbody>
</table>

St: 1 in = 25.4 mm, 1 psf = 0.0479 kN/m²

1. Table values are based on:
   a. Minimum ¾" (19.1 mm) thick wood furring and wood studs of Spruce-Pine-Fir (SPF) or any softwood species with a specific gravity of 0.42 or greater per NDS.
   b. Minimum 33 mil steel hat channel furring of 33 ksi steel. Steel hat channel shall have a minimum ¾" (22.2 mm) depth.
   c. Steel framing of indicated nominal steel thickness and minimum 33 ksi steel for 33 mil and 43 mil steel and 50 ksi steel for 54 mil steel or thicker.

2. Self-drilling, self-tapping screw fasteners for connection of siding to steel framing shall comply with the requirements of AISI S200. Other approved fasteners of equivalent or
5.4  The minimum fastening requirement shall be the more stringent of that required by:

5.4.1  Fastening schedule determined in accordance with Section 5.3 of this research report.

5.4.2  Fastener type, head size, diameter, spacing, and penetration into framing required by the applicable building code for the specific cladding material and the cladding manufacturer’s installation instructions.4,5

5.4.2.1  Where the seismic provisions of IRC Section R301.2.2 apply, the wall assembly shall not exceed the weight limits of IRC Section R301.2.2.1, unless an engineered design is provided in accordance with Section R301.1.3.

5.4.2.2  Where the seismic load provisions of IBC Section 1613 apply, the cladding attachment shall be verified to provide resistance to meet or exceed minimum required earthquake loads.

5.4.3  Fastenings that are not at least equivalent to minimum required fastener characteristics described in Section 5.4.3 shall be designed to provide adequate support of cladding weight, resistance to wind loading, and seismic loads as required by the applicable building code.

5.4.4  For furring connections in accordance with Table 2, allowable wind load resistance shall be verified to meet or exceed the minimum required wind load of the applicable code:

5.4.4.1  Refer to IRC Table R301.2(2) for components and cladding wind loads for the applicable wall wind zone and for an effective wind area of 10 square feet.

5.4.4.2  For IBC required wind loads, see IBC Section 1609.

5.5  Where the application exceeds the limitations set forth herein, design shall be permitted in accordance with accepted engineering procedures, experience, and technical judgment.

6  INSTALLATION

6.1  Verify that materials comply with the following provisions of this research report:

6.1.1  XPS materials shall comply with the requirements of Section 4, unless otherwise approved by the manufacturer evaluation report for the product and thickness intended.

---

4 An example of this would be lath attachments for stucco where a maximum of 7" o.c. spacing is required.

5 IRC Section RT03.3 (2012 IRC Section RT03.4) provides a prescriptive table for the attachment of furring to resist up to 30 psf design wind loading.
6.2 Wall framing materials shall comply with Section 5, specifically the minimum wood and cold-formed steel framing member requirements in the footnotes to Table 1 and Table 2, as applicable.

6.3 Cladding or furring fastener type and size, including fastener length to obtain required penetration into or through framing members, complies with the solution determined in accordance with Section 5.4.

6.3.1 Where fasteners are permitted to penetrate into or fully through sheathing or nailable substrate without penetrating into framing, as specified by the manufacturer’s instructions and supported by a test report, the end of the fastener shall extend a minimum of ¼” beyond the opposite face of the sheathing or nailable substrate in accordance with IRC Section R703.11.1.

6.4 Fasteners shall be installed into framing members and driven flush and snug such that gaps between layers are removed, except where a gap under the cladding fastener head is required for attachment of vinyl siding.

6.5 Fasteners shall be installed in a workmanlike manner and not over-driven, resulting in material damage or excessive distortion of cladding, furring, or XPS materials.

6.6 Ensure framing members or blocking are provided to allow for attachment of siding and trim materials at transitions such as corners and wall penetrations. Ensure that a code compliant water-resistive barrier system and flashing are provided prior to or during the installation of cladding materials.

6.7 Where required by contract documents, the project owner or owner’s agent, or good practice, construct a mock-up assembly to demonstrate constructability and a proper integration of components.

6.8 Installation shall comply with the manufacturer’s installation instructions and this DRR. In the event of a conflict between the manufacturer’s installation instructions and this DRR, the more restrictive shall govern.

7 TEST ENGINEERING SUBSTANTIATING DATA

7.1 ABTGRR 1503-02: Attachment of Exterior Wall Coverings Through Foam Plastic Insulating Sheathing (FPIS) to Wood or Steel Wall Framing, Applied Building Technology Group.

7.2 ANSI/AWC NDS: National Design Specification (NDS) for Wood Construction

7.3 AWC TR 12: General Dowel Equations for Calculating Lateral Connection Values

7.4 AISI S100: North American Specification for the Design of Cold-formed Steel Structural Members

7.5 Fastening Systems for Continuous Insulation, New York State Energy Research and Development Authority, 2010.


7.7 Some information contained herein is the result of testing and/or data analysis by other sources which conform to IBC Section 1703 and relevant professional engineering law. DrJ relies on accurate data from these sources to perform engineering analysis. DrJ has reviewed and found the data provided by other professional sources to be credible.

7.8 Where appropriate, DrJ’s analysis is based on design values that have been codified into law through codes and standards (e.g., IBC, IRC, NDS®, and SDPWS). This includes review of code provisions and any related test data that aids in comparative analysis or provides support for equivalency to an intended end-use application. Where the accuracy of design values provided herein is reliant upon the published properties of commodity materials (e.g., lumber, steel, and concrete), DrJ relies upon the grade mark, stamp, and/or design values provided by raw material suppliers to be accurate and conforming to the mechanical properties defined in the relevant material standard.

8 FINDINGS

8.1 The design procedure and installation requirements outlined in this research report may be used to attach exterior wall coverings through foam sheathing to wood or steel wall framing.
8.2 *IRC Section R703.3* and *Section R703.15 through Section R703.16* include provisions for the attachment of cladding and/or furring over XPS to appropriately resist the required design wind loads.

8.3 *IBC Section 104.11 (IRC Section R104.11 and IFC Section 104.9 are similar)* states:

**104.11 Alternative materials, design and methods of construction and equipment.** The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code...Where the alternative material, design or method of construction is not approved, the building official shall respond in writing, stating the reasons the alternative was not approved.

8.4 This product has been evaluated in the context of the codes listed in Section 2 and is compliant with all known state and local building codes. Where there are known variations in state or local codes applicable to this evaluation, they are listed here.

8.4.1 No known variations

9 **CONDITIONS OF USE**

9.1 The attachment of cladding materials through the XPS described in this research report comply with the *IBC* and *IRC*, or are a code compliant alternative as specified in the codes listed in Section 2 subject to the following conditions:

9.1.1 Installation shall comply with the manufacturer’s installation instructions and this research report. In the event of a conflict between the manufacturer’s installation instructions and this research report, the more restrictive shall govern.

9.1.2 Installation shall be on exterior walls with code compliant wood framing or cold-formed steel framing meeting the minimum requirements as indicated in Table 1 and Table 2.

9.2 Where required by the building official, also known as the authority having jurisdiction (AHJ) in which the project is to be constructed, this DRR and the installation instructions shall be submitted at the time of permit application.

9.3 Any generally accepted engineering calculations needed to show compliance with this DRR shall be submitted to the AHJ for review and approval.

9.4 **Design loads** shall be determined in accordance with the building code adopted by the jurisdiction in which the project is to be constructed and/or by the Building Designer (e.g., owner or registered design professional).

9.5 At a minimum, this product shall be installed per Section 6 of this DRR.

9.6 These products are manufactured under a third-party quality control program in accordance with *IBC Section 104.4 and 110.4 and IRC Section R104.4 and R109.2.*

9.7 The actual design, suitability, and use of this DRR, for any particular building, is the responsibility of the owner or the owner's authorized agent. Therefore, the DRR shall be reviewed for code compliance by the building official for acceptance.
10 IDENTIFICATION

10.1 The foam sheathing described in this research report is identified by a label on the board or packaging material bearing the manufacturer’s name, product name, label of the third-party inspection agency, and other information to confirm code compliance.

10.2 Additional technical information can be found at the respective FSC member websites found at fsc.americanchemistry.com/Members.

11 REVIEW SCHEDULE

11.1 For the most recent version or current status of this DRR, visit drjengineering.org or contact DrJ Engineering.