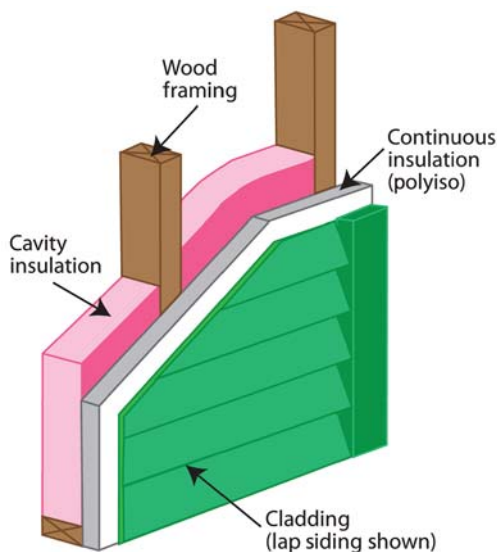


# CONTINUOUS INSULATION FOR CODE-COMPLIANT, HIGH-PERFORMANCE EXTERIOR WALLS

By Jay H. Crandell, PE

## INTRODUCTION

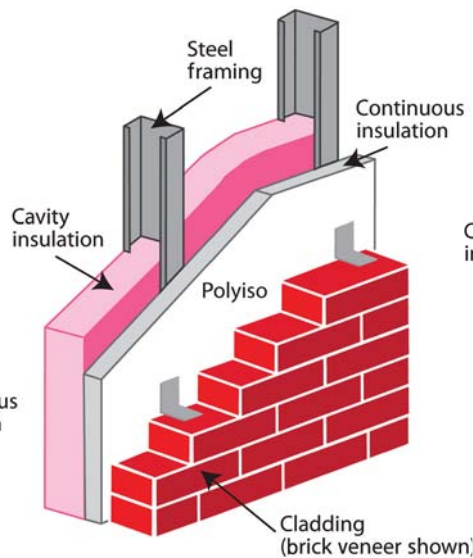
National model energy codes are advancing the way in which we approach building commercial and residential exterior walls by emphasizing the use of continuous insulation (CI) systems, which provide a continuous insulation layer over an entire wall, not just in the wall cavities. Building science experts and energy-efficiency programs such as EnergyStar™ have known for some time that CI is a very effective way to insulate building envelopes for energy savings. Now, modern building and energy conservation codes are putting this knowledge into mainstream practice in response to national interest, resulting in policy to better conserve energy.



## WHAT IS CONTINUOUS INSULATION?

Continuous insulation is defined as “insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior [or] exterior, or is integral to any opaque surface of the building envelope.”<sup>1</sup> Figures 1A-1C show several common applications of CI.

As shown in Figure 1A-1C, continuous



Figures 1A-1C – Light frame and mass wall systems with continuous insulation for code-compliant residential and commercial building construction.

insulation can be used with a variety of wall structural systems and cladding materials such as cement board, PC stucco, wood lap, brick veneer, stone, and vinyl siding. Furthermore, CI can be placed on the interior or exterior side of the wall with proper consideration of climate-dependent moisture vapor control code requirements. For example, it is common to place CI on the inside face of foundation walls and also above-grade masonry walls, which is considered a typical practice in Florida where the exterior masonry wall face is parge-coated. Finally, it is possible to use CI alone to meet energy code without any cavity insulation for the ultimate “warm-wall” design.

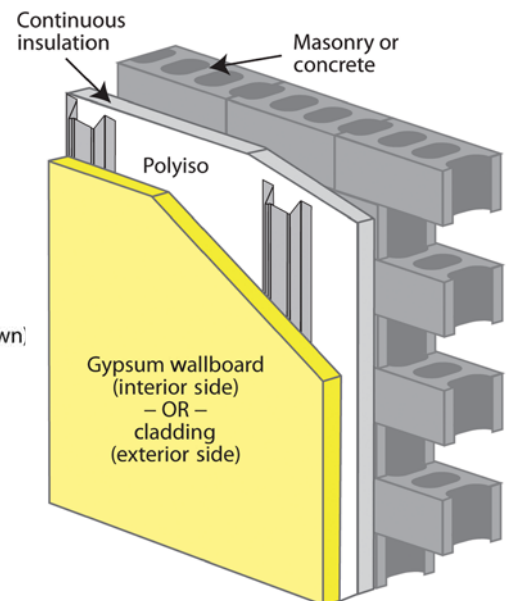


Figure 2A – Cavity insulation only.

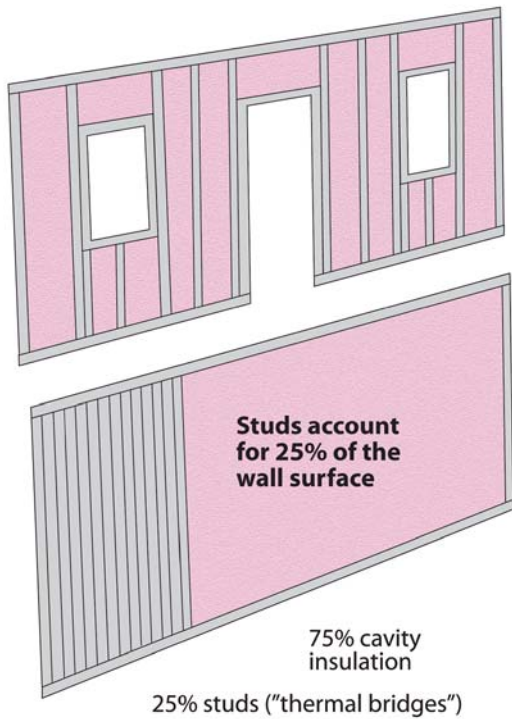
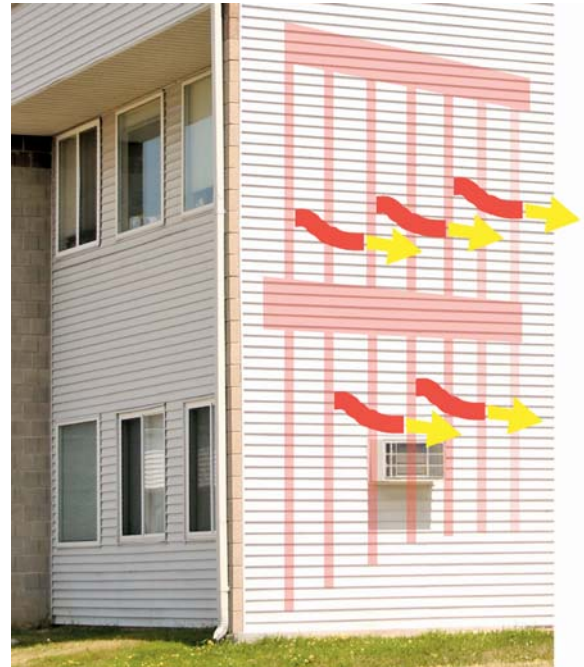


Figure 2B – Cavity insulation only.



**CONTINUOUS INSULATION MATERIALS**

There is a variety of code-compliant foam plastic insulating sheathing materials that can be selected to meet a multiplicity of CI design applications, as discussed above. The most common products are manufactured in accordance with ASTM C578 or ASTM C1289 ([www.astm.org](http://www.astm.org)). Material types include expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (polyiso) foam. Each product type has different thermal properties that affect required thickness, costs, and capabilities (see *Table 1*). Model building code requirements for foam plastics are found in Chapter 26 of the International Building Code and Section R316 of the International Residential Code ([www.iccsafe.org](http://www.iccsafe.org)). A technical bulletin about the use of polyiso insulation as CI can be found at [www.polyiso.org](http://www.polyiso.org).

**ENERGY CODE COMPLIANCE WITH CONTINUOUS INSULATION**

There are at least two good reasons to include CI in exterior wall assemblies: code compliance and high performance. CI provides one of the most thermally efficient ways of complying with modern energy codes. It practically eliminates avoidable heat loss due to thermal bridging in walls that are not continuously insulated (see *Figures 2A–2C*). Modern energy code requirements for walls including CI are shown in *Figure 3*, together with a color-coordinated U.S. climate zone map (*Figure 4*). Clearly, CI plays a significant role in advancing energy codes and best practices for a more energy-efficient future.

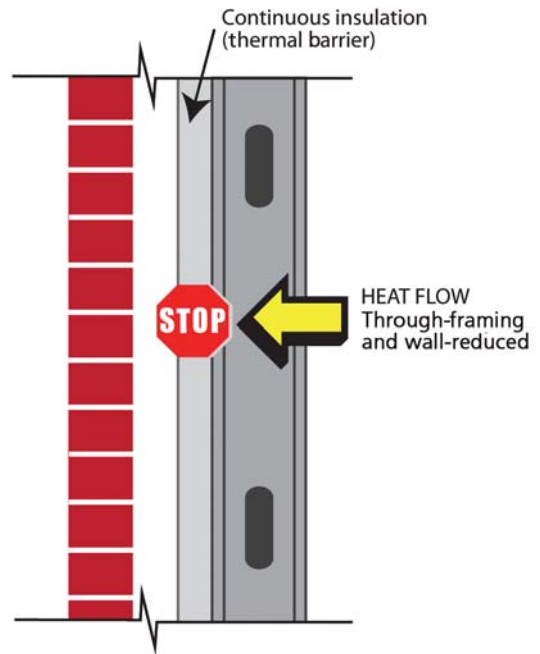


Figure 2C – Wall with continuous insulation.

CONTINUOUS INSULATION MATERIAL TYPE	R-VALUE PER INCH OF THICKNESS
EPS (ASTM C578, Type II)	4.0
XPS (ASTM C578, Type X)	5.0
Polyiso (ASTM C1289, Type 1)	6.0

Table 1 – Examples of R-Value for common types of continuous insulation (foam sheathing).

## 2012 IECC Residential Wall R-value

Installation	Wood Frame R-value	
	2009 IECC	2012 IECC
1	13	13
2	13	13
3	13	20 or 13+R5ci
4 exc. Marine	13	20 or 13+R5ci
4 Marine & 5	20 or 13+R5ci	20 or 13+R5ci
6	20 or 13+R5ci	20+R5ci or 13+R10ci
7 & 8	21	20+R5ci or 13+R10ci

## 2012 IECC Commercial Wall R-value

Climate Zone	Wood Frame	Metal Frame	Metal Bldg	Mass
1	R13+ <b>R3.8ci</b> or R-20	R13+ <b>R5ci</b>	R13+ <b>R6.5ci</b>	<b>R5.7ci</b>
2	R13+ <b>R3.8ci</b> or R-20	R13+ <b>R5ci</b>	R13+ <b>R6.5ci</b>	<b>R5.7ci</b>
3	R13+ <b>R3.8ci</b> or R-20	R13+ <b>R7.55ci</b>	R13+ <b>R6.5ci</b>	<b>R7.6ci</b>
4	R13+ <b>R3.8ci</b> or R-20	R13+ <b>R7.5ci</b>	R13+ <b>R13ci</b>	<b>R9.5ci</b>
5/4 Marine	R13+ <b>R3.8ci</b> or R20	R13+ <b>R7.5ci</b>	R13+ <b>R13ci</b>	<b>R11.4ci</b>
6	R13+ <b>R7.5ci</b> or R20+ <b>R3.8ci</b>	R13+ <b>R7.5ci</b>	R13+ <b>R13ci</b>	<b>R13.3ci</b>
7	R13+ <b>R7.5ci</b> or R20+ <b>R3.8ci</b>	R13+ <b>R7.5ci</b>	R13+ <b>R13ci</b>	<b>R15.2ci</b>
8	R13+ <b>R15.6ci</b> or R20+ <b>R10ci</b>	R13+ <b>R7.5ci</b>	R13+ <b>R13ci</b>	<b>R25ci</b>

Figure 3 – Modern energy-code R-value requirements for commercial and residential building walls (ci = continuous insulation).

1. IECC = International Energy Conservation Code published by the International Code Council, Inc. Refer to ASHRAE 90.1 for alternate code-compliant wall R-values.
2. Wall R-values are shown as cavity insulation alone or as XX + X where the first number is the cavity insulation R-value and the second is for continuous insulation. Continuous insulation “ci” R-values are shown in red.
3. The commercial wall R-values are based on all commercial building-use groups, except R (residential), which may require additional continuous insulation R-value depending on climate zone.
4. Refer to climate zone map (Figure 4) for geographic extent of climate zones listed in Figure 3.

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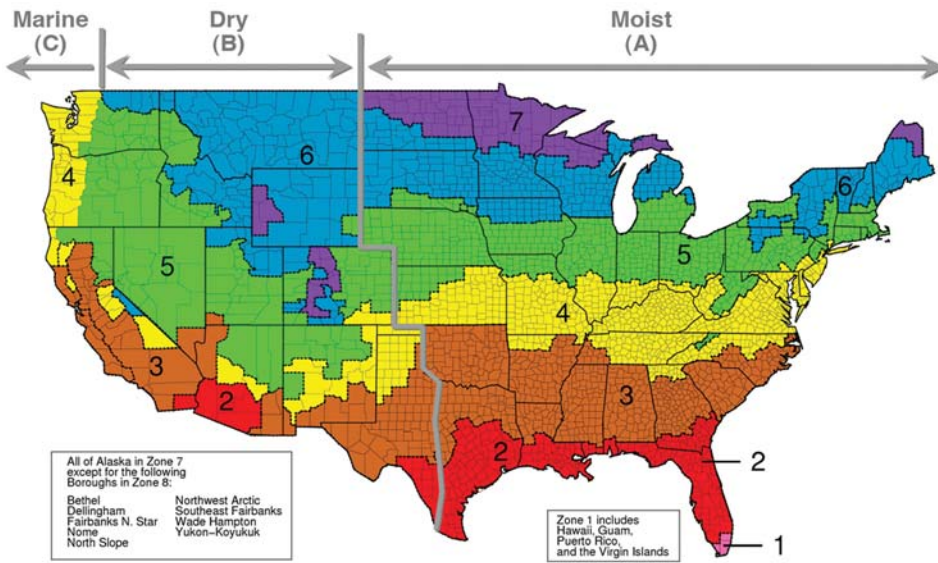


Figure 4 – U.S. Climate Zone Map. Source: 2006 International Energy Conservation Code (IECC).

### BUILDING CODE COMPLIANCE WITH CONTINUOUS INSULATION

Fortunately, there are many options available to arrive at an optimal, building-code-compliant exterior wall assembly using CI. To begin, CI may be used as over-sheathing or as the sole sheathing layer on the outside of an exterior wall. Over-sheathing is simply the installation of CI directly over a solid wall (like masonry or concrete) or over solid structural sheathing such as wood structural panels or gypsum sheathing. Which approach to use is best determined by proper consideration and coordination of interrelated design decisions. For example, if structural sheathing is used as wall bracing, an exterior application of CI must be done as over-sheathing (unless the structural sheathing is installed over the CI, and bracing capacity is adjusted accordingly).

Or, if an exterior fire-rated assembly is required (e.g., very small building separation distances), the CI may be placed over a layer of Type X gypsum sheathing. Conversely, if X-bracing is used to brace exterior bearing walls (or for typical non-load-bearing curtain walls), CI can be used as the sole sheathing layer (including interior sheathing/finish as required). Thus, the decision to over-sheath with CI or use it as the primary sheathing layer must be integrated with other building design decisions.

Some other important wall design and building code-compliance considerations include those explored below.

**Water-Resistive Barrier** – Many CI products can be used as a code-compliant, water-resistive barrier layer behind cladding. Sheathing joints and interfaces with other wall components must be properly flashed by an approved means, usually by application of a durable flashing tape and mechanical flashings as appropriate. Refer to manufacturer installation instructions and code-compliance data.

**Wind Pressure Resistance** – When used as the sole sheathing layer on the exterior side of an exterior wall, CI must be capable of resisting design wind pressure. Fortunately, many code-compliant CI solutions are available. Refer to Technical Evaluation Report TER No. 1006-01, “Prescriptive Wind Pressure Performance of Foam Plastic Insulation Used as Insulating Sheathing in Exterior Wall Covering Assemblies” ([www.foamsheathing.org](http://www.foamsheathing.org)). For specific products, refer to the manufacturer’s installation instructions and design data. Be sure to verify the wind pressure resistance of other wall assembly components, including framing and siding. Wind pressure testing of CI has shown that the wall assembly capacity may be governed by framing, connections, or siding, not the CI material.

**Cladding (Siding) Attachment** – Cladding attachments must provide the required wind pressure resistance (attachment to framing behind foam sheathing) and must also cantilever through the foam sheathing to support the weight of the cladding and

also furring, if used. Various proprietary and standard fasteners can be used for this purpose, based on recent testing sponsored by the Foam Sheathing Coalition (FSC), the New York State Energy Research and Development Authority (NYSERDA), and the Steel Framing Alliance. For additional information and design guidance, refer to the FSC’s *Tech Matters* “Guide to Attaching Exterior Wall Coverings Through Foam Sheathing to Wood or Steel Wall Framing” ([www.foamsheathing.org](http://www.foamsheathing.org)). This document provides code-compliant fastening recommendations for cladding weights ranging from <3 psf to 25 psf and foam thicknesses ranging from ½ to 4 in. Requirements are also provided for attachment of wood or steel furring such that cladding attachments do not need to penetrate the CI layer. Similar fastener requirements have also been adopted into the 2010 New York State Energy Code.


**Fire Performance** – Foam plastics are held to a very comprehensive set of fire performance requirements which, in some cases, exceed those applied to other materials. As mentioned, these requirements are found in IBC Chapter 26 and IRC Section R316. The requirements include various types of fire tests and criteria to address flame spread, smoke development, ignition protection, etc. By far the most significant code requirement that applies to walls with continuous insulation (foam plastics) is the NFPA 285 flame spread test, which uses full-scale, multistory wall assemblies. With appropriate installation details, material properties, and wall assembly components, a substantial number of wall assembly variations have passed the requirements of NFPA 285, and that number is growing steadily. For more information, refer to FSC’s *Tech Matters*’s “NFPA 285 Tested Assemblies Using Foam Sheathing” ([www.foamsheathing.org](http://www.foamsheathing.org)) and the manufacturer’s technical data to be sure the latest available information is used.

It is interesting to note that some common code-compliant wall assemblies using materials other than CI are unable to pass the NFPA 285 test. But this is just a further indication that code-compliant continuous insulated walls are fire-safe. Finally, wall assembly compliance with NFPA 285 is not required for buildings meeting limitations for Type V construction or otherwise designed with height and area sizes with use of fire separation walls to allow consideration as Type V construction. NFPA 285

compliance also is not required for one- and two-family dwelling construction.

**CONCLUSION**

Continuous insulation or “CI” can be integrated into exterior wall assemblies in many ways to provide code-compliant, high-performance wall constructions. CI can serve several important functions, including continuous thermal insulation, moisture vapor control, water-resistive barrier, and air barrier. Some proprietary insulated sheathing laminates can even be used as structural bracing. When used as a multi-functional sheathing, CI simplifies the steps to construct a code-compliant, high-

performance wall assembly. For more information on the advantages of continuous insulation over other noncontinuous insulation wall sheathing choices, refer to “Overview of Wall Sheathing Options: The Value of Foam Sheathing as a Wall Covering” ([www.foamsheathing.org](http://www.foamsheathing.org)). 

**FOOTNOTE**

1. ASHRAE 90.1-2007, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA.,

**Jay Crandell, PE**

Jay Crandell, PE, (d/b/a ARES Consulting) has over 22 years of experience in building codes and standards development, innovative building technology research, construction, and design. ARES Consulting serves the technical needs of government agencies, associations, manufacturers, builders, and owners. For more information, refer to [www.aresconsulting.biz](http://www.aresconsulting.biz).



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Look for references to SFB and CS-SFB in tables and figures in sections R602.10 and R602.12.

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