CAPTURING THE THERMAL PERFORMANCE OF FOAMULAR® EXTRUDED POLYSTYRENE (XPS) vs. POLYISOCYANURATE (POLYISO) FAQs

Q: Why is rigid foam insulation specified in exterior wall assemblies?

A: When used in continuous insulation (ci) applications, rigid foam insulation increases the thermal resistance of the wall assembly by minimizing thermal bridging caused by framing members. For example, in an average wood frame construction, wood framing accounts for approximately 25 percent of the overall wall surface that is left un-insulated when only the stud cavities are insulated.[1] Similarly, in steel framed construction, the steel not only interrupts the stud cavity insulation, it is also a very good conductor of heat.

Rigid foam insulation can be installed directly over framing members to provide continuous insulation coverage across the entire exterior of the wall. This approach enhances the thermal resistance of the wall and also reduces potential for moisture and mold issues within the wall assembly.

Q: Why do cold months matter most when it comes to selecting a rigid insulation?

A: During cold winter months, buildings experience significant heat flow movement from inside to outside. To address this heat flow transfer, it's critical to specify a reliable insulation solution to achieve the desired energy efficiency, building performance and occupant comfort. New third-party research illustrates that Extruded Polystyrene (XPS) provides more reliable thermal performance than Polyisocyanurate (polyiso).

Q: Can the Federal R-value Rule mislead specifiers regarding the actual thermal performance of rigid insulation?

A: In some cases, yes. Across the industry, the U.S. Federal R-value Rule regulates that all R-value claims labeled and marketed for insulation products must be based on ASTM C518 tests[2]. A standard mean temperature of 75°F is used when performing ASTM test methods for determining a material's R-value. In the case of rigid foam insulation, this can be problematic.

XPS has a published R-value of R5.0 per inch and polyiso is listed at a range of R5.6 to R6.0 per inch.[3] These values are true when tested at a mean temperature of 75°F. However, building science research continues to show that the R-value of each product is substantially different when tested at colder mean temperatures. In other words, insulation R-value is temperature dependent.

As shown in the table below, the R-value of polyiso can *decrease* substantially when tested at mean temperatures less than 75°F. In contrast, the R-value of XPS can actually *increase* in colder temperatures. In fact, XPS outperforms polyiso in cold, winter months when it matters most.

Mean Temperature	XPS	Polyiso
75°F	R5.0	R5.6
15°F	R6.0	R2.0

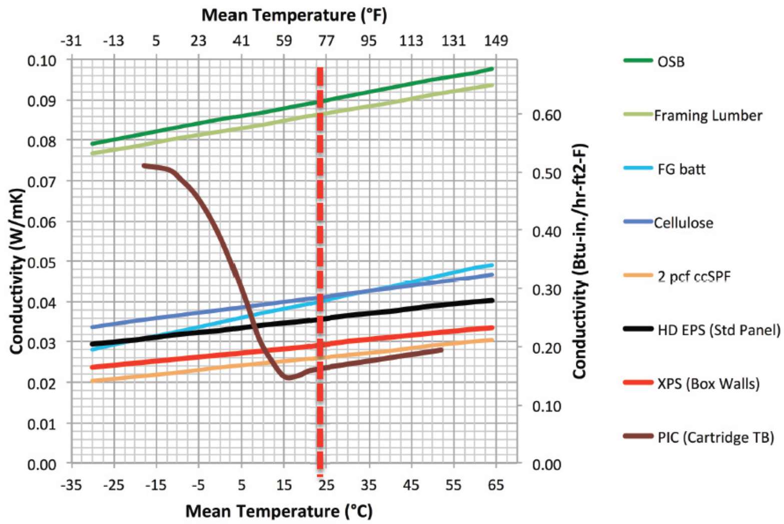
Q: What new research substantiates that XPS exhibits better thermal performance than polyiso as temperatures get colder?

A: Recently, Building Science Corporation (BSC) published the *Thermal Metric Summary Report*[4] regarding their Thermal Metric Project and Reference Wall testing. The long-term goal of this project was to develop a new metric for the thermal performance of building enclosures that better accounts for known physical heat flow mechanisms (particularly natural and forced convection) and operating conditions. This project included a focus on better understanding the thermal conductivity of insulating materials at different mean temperatures. The report reveals that the thermal performance of XPS and many other insulation types improves as the temperature drops. However, polyiso doesn't follow the same pattern. In fact, the BSC report illustrates that the thermal performance of polyiso declines substantially as the temperature drops.

As part of their research, BSC tested the thermal conductivity of polyiso and several other building materials (See Figure 1). At 75°F, the mean temperature at which insulation R-values are reported on consumer packaging, the polyiso sample (shown as "PIC Cartridge TB" below) exhibits a level of thermal conductivity which correlates to its published R-value (R-value = 1 divided by its thermal conductivity, BTU-in/hr-ft2-F).

However, as the temperature drops below 59°F, its thermal conductivity increases substantially which results in a significant decrease in R-value. In contrast, the thermal conductivity of XPS decreases as the temperature drops, resulting in an R-value that is ultimately greater than R5.0 per inch.

Figure 1. Thermal conductivity test results from Building Science Corporation[4]



Measured Temperature Dependency of Selected Materials from the TM Research Project

Q: Why does most polyiso perform so poorly when the temperature declines?

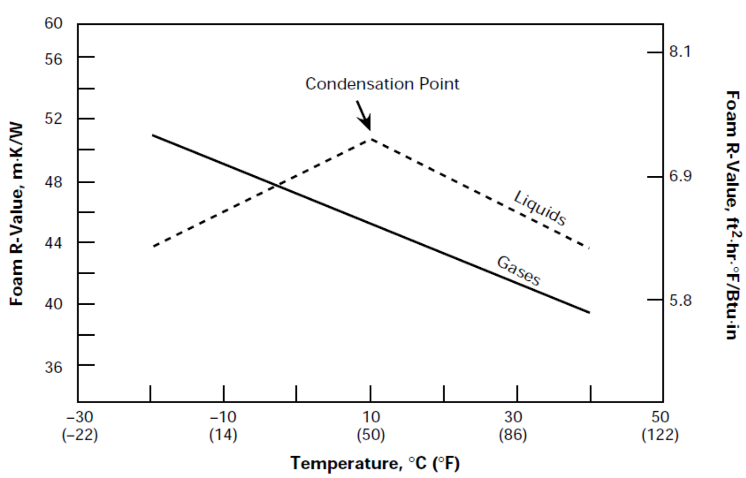
A: The increased thermal conductivity and inconsistent performance of most polyiso is primarily attributed to the amount and type of blowing agent used in the product. The blowing-agent (insulating) gases that are entrapped within the cells of most polyiso begin to condense at colder temperatures and, as those gases condense, the thermal conductivity of the blowing agent and in turn, the polyiso increases.

The blowing agent (insulating) gases that are entrapped within the cells of the XPS remain as a gas over the tested temperature range. As the temperature gets colder the thermal conductivity of the gaseous blowing agent decreases and in turn, the thermal conductivity of the XPS decreases. Figure 2 uses averaged data to illustrate the effect of blowing agent boiling point on a foam's insulation value. This data demonstrates one of the advantages of low-boiling blowing agents: improved insulation performance over a broader operating temperature range. And, the better the insulation performance, the lower the energy consumption of products that rely on these high-value foam insulations.[5]

Due to this degradation of most polyiso's thermal performance in colder temperatures, builders and specifiers are paying a premium for a product that does not deliver on the intended thermal performance.

In contrast, XPS is manufactured in a continuous extrusion process that produces a homogeneous closed cell crossed section. Even when exposed to freeze-thaw cycling conditions in colder temperatures, XPS maintains its closed cell structure and is virtually impervious to moisture, preventing loss of R-value due to moisture penetration.

Figure 2. Foam Insulation Value Versus Temperature for Liquid and Gaseous Blowing Agents[5]



Q: Since the R-value of polyiso is severely compromised in cold temperatures, how does polyiso ci compare to XPS ci in a typical wall assembly?

A: Together with Building Science Corporation (BSC), the Owens Corning building science team used WUFI, a well-respected hygrothermal modeling program, to analyze the performance of XPS and polyiso in a variety of U.S. climates using BSC measurements. Three cold-climate locations in Chicago, Toronto, and Minneapolis were measured along with one hot-climate location in Miami.

Exterior wall types (each with brick veneer cladding) were evaluated, including:

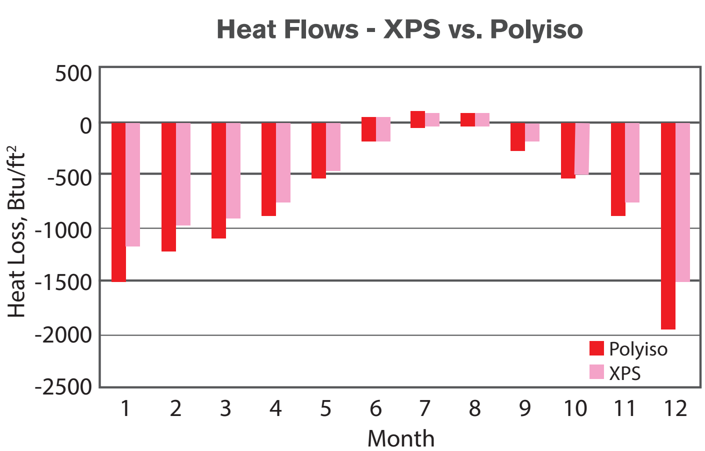
- 2x4' wood-framed, fiberglass-insulated wall with XPS continuous insulation
- 2x4' wood-framed, fiberglass-insulated wall with polyiso continuous insulation

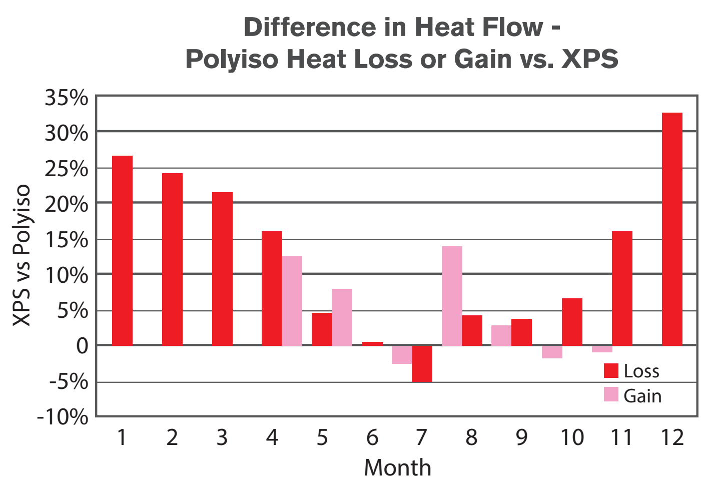
Using the test data from BSC, the Owens Corning building science team ran WUFI simulations to take into account the actual thermal conductivity behavior of polyiso at different temperatures.

The WUFI results for Chicago (Figure 3) are expressed in terms of heat loss and heat gain on a month-by-month basis. As shown, both XPS and polyiso wall assemblies perform about the same during the summer. However, in the winter months, it's clear that walls built with XPS perform better than those constructed with polyiso. On an annual basis, the heat flow results show that 2 inches of XPS is 21 percent more efficient than polyiso (1 inch of XPS is 12 percent more efficient than polyiso).

This testing conclusively found that the XPS (with a published R-value of 5.0 per inch) performs 30 percent better than the polyiso (with a published R-value of 5.6-6.0 per inch) at 50°F mean temperatures. In fact, measurements taken in Chicago during peak cold temperatures in December found that a wall with two inches of polyiso ci enabled 30 percent more heat flow through the wall versus the same wall with two inches of XPS.

Figure 3. WUFI results for Chicago climate featuring heat flows
(R10 board for both XPS and polyiso)





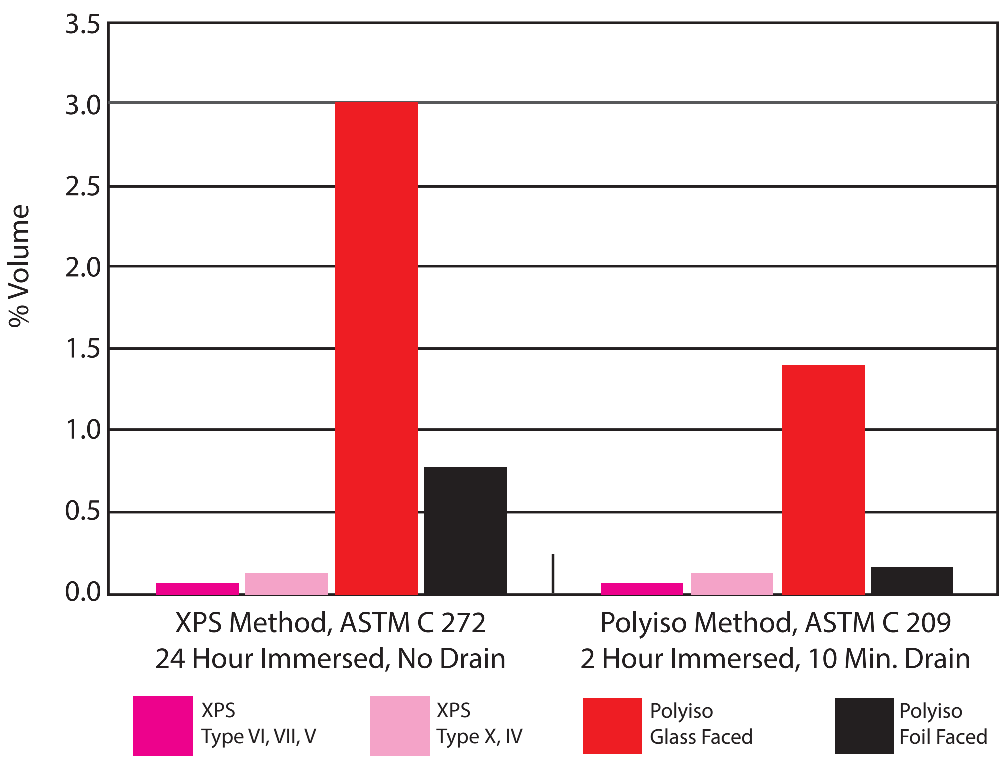
Q: How do XPS and polyiso water absorption properties compare?

A: The material standard that defines properties for all XPS and EPS is ASTM C578.[6] It requires that polystyrene insulation be tested for water absorption in accordance with ASTM C272.[7] C272 requires the polystyrene sample to be immersed in water for 24 hours, and weighed immediately upon removal from immersion to determine the amount of absorbed water. The material standard for polyiso is ASTM C1289.[8] It requires that polyiso be tested for water absorption in accordance with ASTM C209.[9] C209 requires the polyiso sample to be immersed in water 2 hours, and drained for 10 minutes before weighing for water absorption. Figure 4 shows the significant differences in XPS and polyiso water absorption that result from using different measuring techniques. Note that the water absorption level for polyiso increases greatly when tested by the same method used for XPS. Glass faced polyiso goes from absorbing 14x more water than XPS, to absorbing 30x more water than XPS, when measured using the same method. Foil faced polyiso goes from absorbing 1.5x more water than XPS, to absorbing over 7x more water than XPS. Because the presence of foil makes such a difference in water absorption, the long-term durability of the foil is critical. If the foil is punctured or corrodes while in service, the polyiso core is unprotected from water, and is even more prone to higher water absorption, like the condition with glass facers.

Q: Why does water absorption resistance matter when it comes to selecting a rigid insulation?

A: Moisture gets into all types of buildings. Unless the building insulation is highly resistant to water absorption, moisture can degrade insulation R-value, structural integrity and provide an essential ingredient to support mold growth. Water is a good conductor of energy, so if insulation is water soaked, R-value is lost. Also, compressive strength may be reduced by water absorption depending on the make-up of the foam plastic insulation, hydrophobic/closed cell XPS or hydrophilic/more open cell polyiso. Therefore, absorbed moisture is to be avoided to achieve sustainable quality construction. One of the greatest attributes of XPS is its ability to retain R-value and compressive strength even when exposed to water.

Figure 4. Water Absorption, XPS vs. Polyiso



Q: Why is this scientific data relevant to specifiers and builders?

A: Armed with scientific data, builders and specifiers can avoid getting shortchanged on the intent of their high-performance building design ***by specifying XPS rather than polyiso***.

The differences in thermal performance identified in both BSC scientific studies illustrate the fact that comparing thermal conductivity values at a 75°F mean temperature is not always an appropriate indicator of the thermal resistance under actual field conditions.

With many of today's specifiers and builders focused on high-performance building, XPS insulation has been scientifically found to deliver a better performing and more cost-effective solution than polyiso in markets with colder temperatures.

Ultimately, ***selecting XPS rather than polyiso*** can reduce material costs and achieve improved thermal performance, making it an easy choice for specifiers and builders who are informed of the facts. As a result of this third-party scientific data, cold-climate builders and specifiers may want to adjust their approach to selecting rigid foam insulation based exclusively on R-values.

Q: What are the sustainability attributes of Owens Corning® FOAMULAR® XPS?

A: Available in a variety of compressive strengths, Owens Corning® FOAMULAR® XPS insulation delivers exceptional moisture resistance and provides long-term durability and performance by retaining its high R-value. In addition it is a recyclable material with the following recognition:

- FOAMULAR® XPS is the first XPS with a third party, independently certified, minimum 20% recycled content by SCS Global Services.
- FOAMULAR® XPS is the only XPS that is GREENGUARD Gold certified.
- FOAMULAR® XPS has an industry-leading lifetime limited warranty* across all thicknesses and compressive strengths.

Q: Where can I find more information?

A: For more about Owens Corning® FOAMULAR® XPS insulation and applications that can benefit from XPS insulation, visit: **www.OCBuildingSpec.com**.

For more information about the Building Science Corporation testing, read the *Thermal Metric Summary Report*[4]. Additional resources are available via phone call at **1-800-GET-PINK**.

1 2013 ASHRAE Handbook of Fundamentals (HoF) p. 27.3
2 http://www.astm.org. C518.
3 http://www.astm.org. C578. C1289.
4 Thermal Metric Summary Report. Building Science Corporation. http://www.buildingscience.com/documents/special/content/thermal-metric/BSCThermalMetricSummaryReport_20131021.pdf, 2013.
5 DuPont™ Formacel®. "Temperature Effect on the Insulation Value of Polyurethane Foams," 2011.
6 ASTM C 578-06, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959
7 ASTM C 272, Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions; ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959
8 ASTM C 1289-06, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board; ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959
9 ASTM C 209, Test Methods for Cellulosic Fiber Insulating Board; ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959

*For the life of the home or building. See actual warranty for complete details, limitations and requirements.

SCS Global Services provides independent verification of recycled content in building materials and verifies recycled content claims made by manufacturers.
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