Comparing Rigid Foam Plastic Insulations

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Foamular® Extruded Polystyrene Insulation

Owens Corning manufactures a complete line of Foamular® Extruded Polystyrene Insulation (XPS) products for use in building construction. The primary difference between Foamular XPS products is compressive strength that ranges from 15 psi to 100 psi, while possessing an R-value of 5 per inch of thickness. The variety of available strengths enables the designer to select a high strength product suitable for use under floor or plaza deck load; or, an intermediate strength product for use where compressive loads are much lower such as around foundations, or in low slope roofs, or lower strength products for use in walls where there is almost no compressive load.

Closed Cell: What Does it Mean?

Insulation that absorbs water loses R-value. A foam plastic insulation that has a closed cell structure absorbs a minimum amount of water thus retaining R-value. Often all foam plastic insulations are referred to as “closed cell”. It is important to know what “closed cell” means and then relate it to specific insulation types.

Foamular XPS insulation examined under a microscope (Figure 1) can be seen to have very well defined, uniform cells with continuous walls. The cell walls are comprised of hydrophobic polystyrene polymer. That combination of characteristics results in a very low rate of water absorption compared to other types of foam plastic insulation.

Expanded polystyrene (EPS) insulation (Figure 2) is comprised of polystyrene beads fused together under heat and pressure. Although the beads themselves are closed cell and hydrophobic, the air spaces between them allow water and air to penetrate the board structure. The air spaces lower the R-value of the board because air has a higher thermal conductivity than the gas in the cells. The air spaces also provide a path for water penetration, raising water absorption.

Polyisocyanurate insulation (Figure 3) has a less well defined cell structure, meaning cells tend to be irregular in shape and size and sometimes blended together. Irregular cells, combined with the hydrophilic chemical tendency of polyiso to seek a bond with water, results in higher water absorption compared to XPS.

Figure 1: Extruded Polystyrene Cell Structure

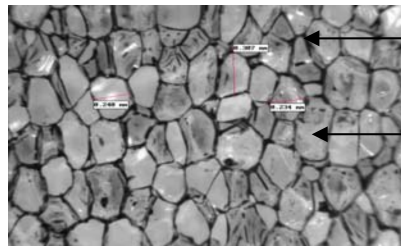


Figure 2: Expanded Polystyrene Cell Structure

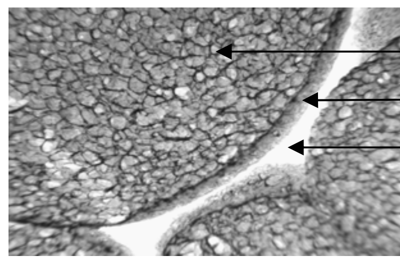
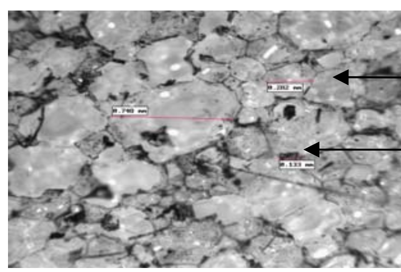


Figure 3: Polyisocyanurate Cell Structure



Comparing Properties: What Do They Mean?

Published properties for different types of insulation are not always directly comparable because different test methods may be used to measure properties. If different methods are used to measure performance, the specifier should identify the differences. They may be significant.

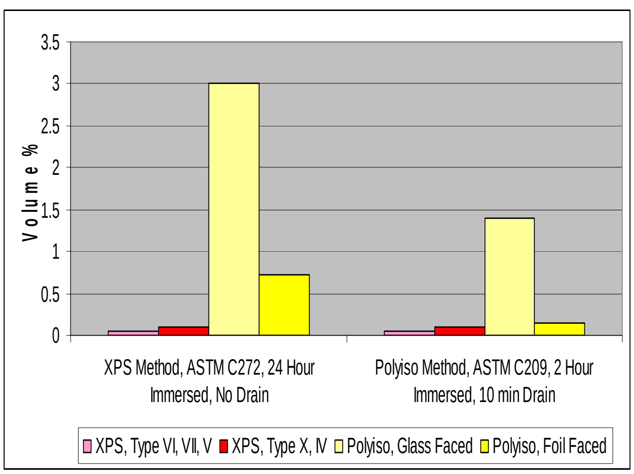
Water Absorption

For example, the material standard for Foamular XPS is ASTM C578.[1] It requires that polystyrene insulation be tested for water absorption in accordance with ASTM C272.[2] 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 polyisocyanurate is ASTM C1289.[3] It requires that polyiso be tested for water absorption in accordance with ASTM C209.[4] 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 water absorption that result from using different measuring techniques. Note that the water absorption level for polyiso greatly increases 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. The long-term durability of the foil is critical because foil facers limit water absorption. If the foil is punctured or deteriorates, the polyiso core is unprotected from water, and becomes more like the condition with glass facers.

Figure 4: Water Absorption, Volume %



R-Value

Test method differences also exist when measuring R-value. R-value changes as foam plastic ages. Long term thermal resistance (LTTR) can be measured using real-time aging, or aging can be artificially accelerated. The XPS industry reports R-value based on real-time 5 year aging. The polyiso industry uses CAN/ULC/S770 [5], to accelerate aged R-value. The S770 method has been shown to overstate LTTR.[6]

Ask Questions to Compare Properties

These examples demonstrate the importance of asking questions to insure that published properties are directly comparable. Specifiers must identify the test methods used to measure properties and if the methods are not identical, ask about the differences.

Moisture and Insulation in Construction

Moisture gets into buildings, all types of buildings. Unless the building insulation is highly resistant to water absorption, moisture can degrade insulation R-value and provide an essential ingredient to support mold growth. Whether it is a retail building, a school building, an office or a freezer building, absorbed moisture is to be avoided to acheive sustainable quality construction. Foamular XPS is an insulation solution to help achieve that goal.

Masonry Cavity Wall Construction

Masonry cavity walls (Figure 5) are rain screen walls designed to deter the penetration of rainwater while equalizing air pressure on opposite sides of the brick face. This allows water that does get in to drain out weep holes at the bottom of the cavity.

Figure 5: Masonry Cavity Wall

Water that enters the air space cavity migrates downward. Along the way it may encounter imperfections in construction like mortar bridges (Figure 6) that conduct it across the air space cavity to the face of the insulation and possibly to the inner masonry wythe.

Figure 6: Mortar Bridging

Foil Facers in Cavity Walls? Ask Questions

The polyisocyanurate insulation industry recommends the use of foil-faced polyiso in masonry cavity wall construction.[7] PIMA Technical Bulletin #401 states, "Foil-faced polyiso insulation is water repellent due to the impervious nature of the facers and the closed cell nature of the foam core. These properties provide long term moisture resistance."[7]

Foil Facers May Deteriorate

An Owens Corning study to evaluate moisture build-up in the cavity air space, conducted by ATI, revealed that the foil facer on a sample of polyisocyanurate insulation deteriorated significantly during the test, especially at the bottom where exposure to moisture was the greatest.[8] (Figure 7)

Figure 7: Cavity Wall, 2 Week Moisture Test

Before Installing Brick **After Removing Brick**

The test specimen consisted of a 12' wide by 8' high standard masonry cavity wall with three types of 2" thick insulation, extruded polystyrene (Figure 7, left sample), foil faced polyisocyanurate (center sample), and spray polyurethane (right sample).

Brick veneer was installed on the wall in accordance with the Brick Institute of America's technical notes on brick construction. Special attention was given to eliminating mortar bridges. Weep holes were ¼" in diameter and located 24" on center horizontally. The cavity wall was a continuous surface with no windows, doors, or flashings for water to penetrate. A one inch air space separated the back of the brick and the face of the insulation samples.

The air space and the insulation samples were instrumented with humidity sensors and thermocouples. The testing followed ASTM E-1105 "Field Determination of Water Penetration of Installed Exterior Windows, Curtain Walls, and Doors by Uniform or Cyclic Static Air Pressure Difference", Test Method A.

Water was sprayed onto the exterior face of the brick wythe at a rate of five gallons per hour per square foot while simultaneously applying a pressure equivalent to a 25-mph wind. The exposure continued for two weeks.

Testing confirmed that water penetrates into the cavity of a masonry cavity wall. Water penetrated through the mortar joints of the outer brick in less than 24 hours. By the fourth day of testing, water was visibly running down the interior of the brick wythe. The relative humidity in the wall cavity ranged between 70% and 90% over the two week test period as water entered the cavity through the brick.

The study substantiated that a wall cavity will at times become wet and humid. The test results show that insulation specified for use in a masonry cavity wall must be inherently closed cell and moisture resistant, and that foil facers may deteriorate and may not be a reliable barrier to improve resistance to water absorption.

Reflective Foil Facers Add R-Value? Ask Questions

PIMA Technical Bulletin #401 states, "Placing the reflective foil-facer so that it faces the cavity allows the designer to add additional R-value to the wall."[7]

In real masonry cavity walls, it is very difficult to achieve added R-value from reflective facers due to the condition of the air space inside the wall cavity. In the ASHRAE Handbook of Fundamentals, it says about the thermal resistance of air spaces with reflective surfaces, "…(R) Values apply for ideal conditions (i.e., air spaces of uniform thickness bounded by plane, smooth, parallel surfaces with no air leakage to or from the space)..."[9] Surface water or condensate and deterioration of the foil surface also reduce the level of added R.

Look at Figures 6 and 7 again. Even in the best of situations, cavities are not plane, smooth or parallel, and they are designed to have some amount of air flow through the cavity to allow air pressure to equalize on both sides of the wall. And, foil surfaces may not endure for the life of the building. Therefore, reflective foil facers don't add R-value in such conditions.

Foamular® Extruded Polystyrene Insulation

Foamular Extruded Polystyrene has high resistance to water because it is closed cell and is composed of hydrophobic polystyrene polymer. It achieves its resistance to water absorption without relying on facers. It has a long term stable thermal resistance of R-5 per inch, measured after real time aging. It is an excellent choice for building insulation applications.

Owens Corning has many insulation and construction products for use in all types of building systems. We have building science expertise to lend to assessing questions on thermal efficiency, moisture management, sound control, air distribution, mechanical and pipe insulation, insulation economics and sustainability.

Contact Owens Corning at 1-800-GET-PINK, or visit our website at www.owenscorning.com.

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