EPS Insulation Advancements
& Technology Innovations

TECHNICAL BULLETIN

EPS Industry Alliance

Use Fully Aged R-values for Insulation & Building Envelope Design

Insulation is critically important and one of the most cost-effective ways to reduce energy consumption in buildings. It reduces the heat flow between the conditioned interior space and the external environment. The resistance to heat flow through the insulation is called "thermal resistance", commonly known as R-value.

It is essential to consider the insulation R-value stability over its lifetime to ensure energy consumption targets are met. While it is generally understood that higher R-value means greater insulating power, many are not aware that the R-value of some foam insulation products will decrease over time. In 2020, the U.S. Federal Trade Commission (FTC) updated its R-value Rule to state that "for polyurethane, polyisocyanurate, and extruded polystyrene, the [R-value] tests must be done on samples that fully reflect the effect of aging on the product's R-value." The rule also requires product labeling with the aged R-value.

Currently, ASTM C578, the standard material specification for expanded (EPS) and extruded (XPS) polystyrene foam insulation, prescribes a short-term (6 months) R-value for XPS insulation, despite the new FTC R-value Rule requirement. In contrast, the corresponding Canadian material specification, CAN/ULC S701.1, requires a minimum predicted R-value at 5 years of age, typically referred to as the Long-Term Thermal Resistance (LTTR).

However, architects and specifiers consider the design service life of typical building structures to be 50 years. The insulation R-value needs to reflect this entire time for material specifications to dictate the correct performance metrics. Therefore, 5-year R-values (LTTR) are insufficient to serve as design value.

In the absence of available information on the aged R-value performance of XPS insulation, a test program conducted by an independent third-party ISO 17025-accredited laboratory was commissioned. The third-party test program evaluated five XPS insulation products, from four North American producers and one European producer. The five products were obtained from commercial sources during 2018-2020.

Third-party test results indicate 50-year aged R-value per inch is 4.0 – 4.7 for XPS insulation.

Test methods have been developed for use as a reliable predictor of the aged R-value for insulation products using a blowing agent that is retained within the foam's cellular structure. Two methods, ASTM C1303 and CAN/ULC-S770, estimate the aged R-value of the insulation at a specific time. Both involve slicing thin sections approximately 3/8" (10 mm) thick from an insulation sample of full thickness. Due to the thin slices, the diffusion and exchange of the retained

gases with air occurs more rapidly. This means the insulation R-value can be predicted for specific points in time within a shorter testing period.

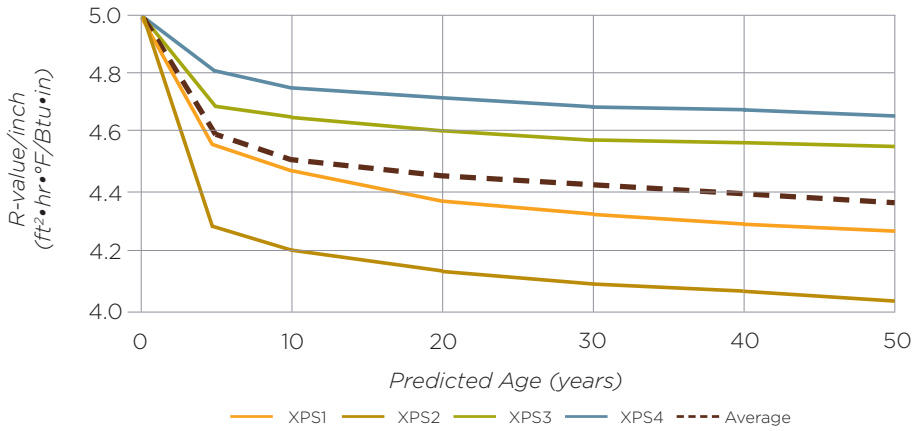
XPS loses R-value as the blowing agent retained in its cells dissipates over time. The exchange of the retained gas with air occurs naturally as the material slowly comes to equilibrium with the environment. Unlike XPS, EPS does not contain a retained blowing agent, but contains only ambient air, and therefore, its R-value is stable and does not decrease over its lifetime. As referenced in ASTM C1303, Sec. 5.1.1, there is no need to accelerate the aging process for expanded polystyrene foam insulation.

XPS Insulation Thickness (XPS1)	50 Year R-value per inch ($ft^2 \cdot hr \cdot °F/Btu \cdot in$)
1 inch (25 mm)	4.2
2 inch (51 mm)	4.3
3 inch (76 mm)	4.4
4 inch (102 mm)	4.5

Importantly, XPS R-value depends on product age but also on the board thickness. It can be predicted for variable thickness, since the accelerated aging of the thin slices occur in the same manner.

Aged R-Value of Four North American XPS Insulation Product Samples

ASTM C578 Type IV or CAN/ULC S701.1 Type 4, Compressive Strength: 25-30 psi, 2 inch thickness



Test Results

For the North American XPS products, the aged R-values were predicted up to 50 years using ASTM C1303 accelerated aging method. At 50 years of age, the predicted R-values per inch ranged from R-4.0 to R-4.7, averaging R-4.4. These values are significantly less than the R-value per inch of 5.0 historically cited by XPS manufacturers. On a relative basis, these 50-year results are 7-20% less than the initial R-value per inch of 5.0, about 12% less on average.

The variation among the aged R-value results also highlight the dependence of XPS product performance properties on each manufacturer's technology. Thus, the aged R-value performance of manufacturers' XPS insulation cannot be assumed to be equivalent.

For comparison, a European XPS product produced without a retained blowing agent was determined to have an R-value per inch of 4.2. This result provides a look at the "terminal" or "steady-state" R-value expected for XPS insulation when its retained blowing agent has completely dissipated.

The Bottom Line

Appropriate design values are an essential starting point for optimizing performance in today's buildings. With increasing building complexity and the growing importance of energy conservation, plastic foams offer design innovation, fast installation, and significant cost savings in addition to their insulating properties. However, these value-added features become irrelevant without using the correct R-values. Relying on an R-value per inch of 5.0 for designing with XPS insulation will likely result in an underperforming building.

References

Federal Trade Commission, 16 CFR Part 460: Labeling and Advertising of Home Insulation: Trade Regulation Rule," 84 FR 20788, May 13, 2019.

ASTM C578-18, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation, ASTM International, West Conshohocken, PA, 2018, www.astm.org

CAN/ULC-S701.1:2017, Standard for Thermal Insulation, Polystyrene Boards, UL Canada

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CAN/ULC-S770-15, Standard Test Method for Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams, UL Canada

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