

Dimensional Stability of Roof Products

About Polyiso Insulation

Polyiso is a rigid foam insulation used in more than 70% of commercial roof construction and offers a continuous insulation solution for commercial and residential wall assemblies. As one of North America's most widely used and readily available building products, Polyiso is a cost-effective insulation option for reducing building energy use and improving the overall service-life of roofs and walls.

The benefits of using Polyiso include:

- High R-value per inch of thickness
- Excellent fire test performance
- Extensive building code approvals
- Cost-effective continuous insulation (ci) solution
- Compatible with most roof and wall systems
- Dimensional stability
- Compressive strength
- Moisture resistance
- Thinner walls and roofs with shorter fasteners
- Long service life
- Preferred insurance ratings
- Virtually no global warming potential
- Zero ozone depletion potential
- Recyclable through reuse
- Recycled content (amount varies by product)
- Regional materials (nationwide production network)
- QualityMark^{CM} certified LTRR-values

Many types of materials can be manufactured into products for use as roof insulation: polyiso foam, polyurethane foam, polystyrene foam, perlite, wood fiberboard, mineral wool, and cellular glass. For all of these insulation materials, dimensional stability is an important physical property. Therefore, most of these materials have some reference to testing requirements for dimensional changes in their particular ASTM or Canadian material specification, but the environmental exposure conditions and, in some cases, even the ASTM test method varies from one product to the next. For example, while the standard specifications for cellular plastic products call for as many as three environmental exposure conditions, the wood fiberboard specification has just one but calls for a different test method than the one used for cellular plastics. Similarly, the mineral wool standard specification calls for only one environmental condition, yet it uses the same test method as cellular plastics. Two other materials, perlite and cellular glass, do not include dimensional stability values at all in their ASTM specification standard.

ASTM C 1289 *Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board* specifies maximum dimensional stability values for polyiso insulation. Polyiso is tested for dimensional stability at three different environmental conditions: -40°F/ambient relative humidity; 158°F/97% relative humidity; and 200°F/ambient relative humidity tested in accordance with ASTM D 2126. The Canadian standard for polyiso, CAN/ULC-S704 *Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced*, uses -20°F/ambient relative humidity; 158°F/97% relative humidity; and 176°F/ambient relative humidity tested in accordance with ASTM D 2126.

Given the variety of test methods and exposure conditions, direct comparison of dimensional stability test results between dissimilar materials is not meaningful and therefore not advised. The purpose of this technical bulletin is to shed light on these various dimensional stability tests and their proper use as comparative tools for similar materials.

What Does Dimensional Stability Mean?

In general, dimensional stability is a measurement of a material's change in dimensions—length, width, thickness—in response to various environmental exposure conditions. The degree of dimensional change is expressed as a percent and is specific to a material.

How Is Dimensional Stability Tested?

The test for dimensional stability of most products is relatively simple: 12" x 12" samples are subjected to various exposure conditions for a specific time duration and then measured. The material shall be tested as manufactured. First, the dimensions of the test specimens are measured to



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the nearest 0.1%. They are then placed in an oven or cold box maintained at the appropriate specified exposure conditions. The test samples are arranged so there is substantially free air circulating around all six sides. After exposure for the specified time, the specimens are allowed to return to room temperature for 2 hours before measuring any dimensional change in length, width or thickness. Distortion of the specimens (such as warpage) is also noted.

How are Exposure Conditions Determined?

The standard exposure conditions are usually elevated temperatures at both ambient and high relative humidity levels and low temperature at ambient relative humidity. The exposure conditions attempt to approximate conditions in which the material might be used. It is important to note that the exposure time and conditions for dimensional stability testing are not the same in all ASTM tests or material specification standards. (See Table 1.) It is also important to note that, despite attempts to approximate environmental conditions, the samples are not tested as they would be installed. Therefore, the results should not be applied to full-sized installed insulation boards, which would have been embedded in asphalt or adhesives or fixed by mechanical fasteners and then covered by an additional insulation layer and membranes.

The significance and use section 4.3 of D2126 prescribes how the results obtained by this test method should be applied:

“Dimensional changes measured by this test method can be used to compare the performance of materials in a particular environment, to assess the relative stability of two or more cellular plastics, or to specify an acceptance criterion for a particular material. The results of this test are not suitable for predicting end-use product performance or characteristics, nor are they adequate for engineering or design calculations.”

This statement on the proper use of dimensional stability test results has important implications. It is completely appropriate to compare the relative performance of materials tested under the same conditions and methods. As clearly stated in ASTM D 2126, the results cannot be used to predict performance on a full-sized 4' x 8' board or performance in a completed roof assembly.

Dimensional Stability Comparisons of Cellular Foam Plastic Insulation

The dimensional stability of polyiso and polystyrene foam roof insulations is determined by ASTM D 2126 *Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging*. As shown in Table 1, one of the major differences between polyiso and polystyrene tests for dimensional stability is that polyiso is tested up to 200°F and polystyrene is not. Many other roofing products are tested at high temperatures since it is not unusual to find temperatures on roofs above 158°F. Even this temperature may be exceeded under dark color roofs where the difference between the surface and ambient air temperatures may be as high as 90°F. (Akbari, *Thermal Performance of the Exterior Envelopes of Buildings VII*, 1998), placing actual temperatures in the 180°F - 200°F range.

How Should Dimensional Stability Test Results Be Used?

The dimensional stability test at the time of manufacture is intended as a Quality Control test, a method for comparing one small-scale sample to another or one type of cellular plastic to another.

The results of dimensional stability should not be used to compare unlike materials, even in a small-scale sample. As stated in the test method itself, dimensional stability test results are not intended to be applied to full-sized insulation boards and doing so is therefore beyond the scope of the test intentions. It should be noted that the maximum percentages included in the standard are not intended to establish compliance in a full-sized, installed insulation board.

Dimensional stability values at -40°F/ambient relative humidity and 158°F/97% relative humidity are comparable for polyiso and polystyrene and are well within the values established by their respective ASTM product standards. However, at 200°F/ambient relative humidity, polyiso reports a change of -0.28 % to +0.28% well below the maximum allowed by ASTM C1289. However, the values for extruded polystyrene are as high as a 47% increase and for expanded polystyrene a 53% shrinkage. A photo of the 200°F/ambient relative humidity exposure at the end of 7 days is shown below:

Table 1: Dimensional Stability Reference Table:

Roof product	Test Method	Sample Size	Exposure Time	Exposure Conditions	Dimension Measured
Cellular Glass ASTM C552	None	-	-	-	-
EPDM Sheet Single Ply Roof Membrane ASTM D4637	D1204	10"x10"	670 hrs±6.7 hrs (black) 166 hrs±1.66 hrs (white)	240±4°F (black & white)	Length and width
Fiberboard ASTM C208	D1037	3"x12"	To equilibrium	68±6°F/90± 5% R.H.	Length
Mineral Wool Roof Insulation Board ASTM C726	D2126	12"x12"	7 days	158±4°F/97± 3% R.H.	Length, width and thickness
Perlite ASTM C728	None	-	-	-	-
Polyisocyanurate ASTM C1289	D2126	12"x12"	7 Days	158±4°F/97± 3% R.H. -40±6°F/Ambient R.H. 200±4°F/Ambient R.H.	Length, width and thickness
Polystyrene ASTM C578	D2126	4"x4"	7 Days	158±4°F/97± 3% R.H. -40±6°F/Ambient R.H.	Length, width and thickness
PVC Sheet Roofing Membrane ASTM D4434	D1204	10"x10"	6 hours	176±2°F	Length and width

1 The test methods for dimensional stability used in ASTM and Canadian standards for EPDM and PVC may differ
2 The Canadian standard for EPDM has been withdrawn; however there are current CCMC listings for EPDM manufacturers partly based on this standard.
3 There is no requirement for dimensional stability in the Canadian standard for mineral fibers boards



All samples were initially 12" x 12" and exposed to 200°F for 7 days:

- #1 - Extruded Polystyrene
- #2 - Polyiso
- #3 - Expanded Polystyrene
- #4 - Extruded Polystyrene

While it is tempting to try to match the dimensional stability of a roof insulation with that of an adhered single ply sheet, the user needs to be careful that the test data represents a true "apples to apples" comparison. Be sure that any comparison of data is derived from the same test method and the same environmental exposure conditions.

Finally, it should be iterated that values for physical properties in ASTM or CAN/ULC product specifications are usually minimum or maximum values depending on the physical property. Many specifications, including those for cellular plastic insulations direct a user to "follow specific product information provided by board manufacturers regarding physical properties, system design

considerations and installation recommendations.” Material specification and test method standards (ASTM and Canadian) are valuable tools, and as such, must be used in the manner for which they are intended. If there are concerns about using a particular product for a job, call the product or system manufacturer BEFORE specifying it or installing that system.

PIMA

For more than 30 years, PIMA (Polyisocyanurate Insulation Manufacturers Association) has served as the unified voice of the rigid polyiso industry proactively advocating for safe, cost-effective, sustainable and energy-efficient construction. PIMA’s membership includes manufacturers of polyiso insulation and suppliers to the industry. The products of PIMA’s members comprise the majority of the polyiso produced in North America.

PIMA produces technical bulletins to address frequently asked questions about polyiso insulation. These publications update and inform architects, specifiers, and contractors about and build consensus on the performance characteristics of polyiso insulation. Individual companies can provide specific information about their respective polyiso products.

For more information on polyisocyanurate insulation, visit www.polyiso.org



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