PIMA Technical Bulletin #107

Dimensional Stability of Roof Products

About Polysio Insulation

Polyiso is a rigid foam insulation used in over 70% of commercial roof construction, in commercial sidewall construction and in residential construction.

The Benefits of using Polyiso include:

- *Quality Mark™ certified LTTR-values*
- *Highest R-value per inch of thickness*
- *Excellent fire test performance*
- *Moisture resistant*
- *Dimensional stability*
- *Superior compressive strength*
- *Extensive building code approvals*
- *Cost effective*
- *Recycled content*
- *Zero ozone depletion potential*
- *Virtually no global warming potential*
- *Preferred insurance ratings*
- *Nationwide availability*
- *Thinner walls and roofs with shorter fasteners*
- *Compatible with most roofing systems*

PIMA and polyiso products have received many environmental awards. These include an honorable mention in the Sustainable Buildings Industry Council's (SBIC) 2003 "Best Practice" Sustainability Awards Program and the U.S. EPA's Climate Protection Award for the association's leadership in promoting energy efficiency and climate protection. The EPA also awarded PIMA and its members the Stratospheric Ozone Protection Award for "leadership in CFC phase-out in polyiso insulation and in recognition of exceptional contributions to global environmental protection."

POLYISO
The top performer.

Dimensional stability is an important characteristic for all roof materials. Products that "grow" with temperature and humidity or "shrink" excessively at low temperatures can cause performance problems in a completed roof system. There are a variety of products used as roof insulations: polyiso foam, polyurethane foam, polystyrene foam, perlite, wood fiberboard, mineral fiber board and cellular glass. Most of these materials have some reference to dimensional changes in their particular ASTM or Canadian material specification, but the exposure conditions and in some cases, even the ASTM test method is different. For example, while the cellular plastic products have as many as three exposure conditions, fiberboard has just one with a different test method. Two of these materials, perlite and cellular glass, do not include dimensional stability values in their ASTM material standard.

ASTM C1289 *Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board* specifies dimensional stability values for polyiso roof insulation. As the "benchmark" insulation product for roof 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 in accordance with ASTM D2126. The equivalent Canadian standard for polyiso, CAN/ULC-S704 *Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced,* uses -20°F; 158°F/97% RH and 176°F in accordance with ASTM D2126.

This technical bulletin discusses the various tests used to measure dimensional stability and the proper use of dimensional stability tests as comparative tools.

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 specific to a material.

How Is Dimensional Stability Tested?

The test for dimensional stability of most products is simple: subject 12" x 12" samples to various exposure conditions and measure their response. First, the dimensions of the test specimens are measured to the nearest 0.1%, 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 circulated around all six sides. After exposure for the specified time, the specimens are allowed to equilibrate 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. When subjected to high temperatures, many materials will exhibit an increase in dimensions. At low temperatures a decrease in dimensions is common.

The choice of exposure conditions will be based on the type of material, the application where the material will be used, and the environmental conditions generally expected for that application. It is important to note that the exposure time and conditions are not the same in all ASTM tests or material standards for dimensional stability. (See Table 1)

***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 D4434 (CAN/CGSB 37-GP-52M)[2]	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 (CAN/ULC-S706)	D1037	3"x12"	To equilibrium	68±6°F/90± 5% R.H.	Length
Mineral Fiber Roof Insulation Board ASTM C726 (CAN/ULC-S702)[3]	D2126	12"x12"	7 days	158±4°F/97± 3% R.H.	Length, width and thickness
Perlite ASTM C728	None	-	-	-	-
Polyisocyanurate ASTM C1289 (CAN/ULC-S701)[4]	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

Dimensional Stability Comparisons of Cellular Foam Plastic Insulation

The dimensional stability of polyiso and polystyrene foam roof insulations is determined by ASTM D2126 *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

Report Summary: *7 Days Dimensional Stability Testing on Various 2.0" Thick Foams*

	% Change	Polyiso A	Polyiso B	Polyiso C	XPS[1]	XPS[1]	EPS[2]
-40°F	Length	-0.06	-0.03	0.03	0.08	0.06	-0.03
	Width	-0.06	0.03	0.03	0.00	0.00	0.00
	Thickness	0.17	0.28	0.13	-0.02	0.09	0.01
158°F/97% R.H.	Length	0.33	0.22	0.53	2.03	1.14	0.11
	Width	0.33	0.39	0.31	0.86	0.39	-0.03
	Thickness	1.23	1.41	0.91	1.38	1.50	-0.05
200°F	Length	-0.22	-0.11	-0.28	42.49	31.78	-53.39
	Width	0.28	0.17	0.08	33.14	24.39	-53.20
	Thickness	0.22	-0.22	-0.10	44.67	47.10	-52.14

1 Extruded polystyrene, C578 TYPE IV
2 Expanded polystyrene, C578 TYPE I
3 Polyiso: C1289 Type II, Class 1, Grade 2; CAN/ULC-S704 Type 2, Class 2. Note: types and classes do not correspond in ASTM and CAN/ULC standards.

in the 180°F - 200°F range.

In a recent test series, 2" x 12" x 12" samples of polyiso, extruded polystyrene and expanded polystyrene were subjected to three environmental conditions: - 40 ± 6°F/Ambient R.H.,158 ± 4°F/97±3% R.H. and 200 ± 4°F/Ambient R.H. Dimensional stability was measured after 7 days of exposure. Results are shown in the chart on the following page.

How Should Dimensional Stability Test Results Be Used?

Dimensional stability values at –40°F and 158°F/97% R.H. are comparable for polyiso and polystyrene and are well within the values established by their respective ASTM product standards. However, at 200°F , 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 53% shrinkage! A photo of the 200°F exposure at the end of 7 days is shown below:

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

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 D2126, the results cannot be used to predict performance on a large 4' x 8' board or how the material may perform in a completed roof assembly

since these conditions have not been evaluated.

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, keep in mind 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 over 20 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 produces technical bulletins in an effort to address frequently asked questions about polyiso insulation. PIMA's technical bulletins are published to help expand the knowledge of specifiers and contractors and to build consensus on the performance characteristics of polyiso. Individual companies should be consulted for specifics about their respective products.

PIMA's membership consists of manufacturers of polyiso insulation and suppliers to the industry. Our members account for a majority of all of the polyiso produced in North America.

SAFETY

Polyiso insulation, like wood and other organic building materials is combustible. Therefore, it should not be exposed to an ignition source of sufficient heat and intensity (e.g., flames, fire, sparks, etc.) during transit, storage or product application. Consult the product label and/or the PIMA members' Material Safety Data Sheets (MSDS) for specific safety instructions. In the United States, follow all regulations from OSHA, NFPA and local fire authorities; in Canada, follow all regulations from Health Canada Occupational Health and Safety Act (WMHIS) and local fire authorities.

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

PIMA
Polyisocyanurate Insulation Manufacturers Association

PIMA
7315 Wisconsin Avenue, Suite 400E, Bethesda, Maryland 20814
Phone: 301.654.0000 • Fax: 301.951.8401
www.polyiso.org • pima@pima.org

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