PIMA Technical Bulletin #105

Fire Test Definitions

Polyiso Insulation: The Product of Choice

About Polyiso 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:

- *Low environmental impact*
- *Virtually no global warming potential*
- *Zero ozone depletion potential*
- *Cost effective, optimized energy performance*
- *Long service life*
- *Recyclable through reuse*
- *Recycled content (amount varies by product)*
- *Regional materials (nationwide production network)*
- *Meets new continuous insulation (ci) standards*
- *Quality Mark™ certified LTTR-values*
- *High R-value per inch of thickness*
- *Thinner walls and roofs with shorter fasteners*
- *Excellent fire test performance*
- *Extensive building code approvals*
- *Preferred insurance ratings*
- *Compatible with most roof and wall systems*
- *Moisture resistance*
- *Dimensional stability*
- *Compressive strength*

PIMA and polyiso products have received many environmental awards. These include an honorable mention in the Sustainable Buildings Industry Council's (SBIC) - "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.

The Importance of Building Codes in Construction

The fire performance of building products has always come under close scrutiny — and for good reason. The structures where people live and work must be safe. It is for this reason that building codes exist, to provide a means to safeguard life and protect the private and public welfare through regulating the design, construction practices, construction material quality, location, occupancy and maintenance of buildings and structures. When regulating materials, many of the model building codes refer to performance standards developed by standard development organizations such as the American Society for Testing and Materials (ASTM). Some building codes and insurance rating organizations also rely on test information from FM Approvals (FM) and Underwriters Laboratories Inc. (UL).

This technical bulletin discusses fire test procedures and applicability of these fire tests to building applications. For further information regarding these tests please consult ASTM, building code authorities or accredited testing laboratories.

Fire Tests for Walls and Ceilings

ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials, is a standard method to assess the spread of flame on the surface of a material. Often referred to as the "Tunnel Test," ASTM E84 involves installing a sample of material 20 inches wide and 24 feet long as the ceiling of a horizontal test chamber. The material is exposed to a gas flame on one end of the tunnel for a period of 10 minutes. The rate of flame front progression on the material is compared to selected standards and calculations made to produce a flame spread rating. Smoke from the fire in the tunnel is measured in the exhaust stack via a light beam to establish smoke developed ratings. ASTM E84 also has a number of other designations, such as UL 723 or NFPA 255.

Since ASTM E84 is a standard laboratory fire test on a single material, numerical ratings derived from E84 are not intended to reflect hazards presented by the test material under actual fire conditions.

ASTM E84: Polyiso Insulation vs. Polystyrene Insulation

Polyiso insulation, a thermoset material, stays intact during the fire exposure in the ASTM E84 test. Polyiso insulation successfully performs by forming a protective char layer and remaining in place during the tunnel test, meeting the necessary ratings dictated by building codes.

Thermoplastic materials, such as polystyrene, perform much differently in the tunnel test. Because the material softens at 165°F and melts at

approximately 200°F polystyrene melts ahead of the fire front and drips to the floor of the tunnel where it can continue to burn and spread the fire.

Although many polystyrene insulations claim a flame spread of less than 25, an examination of a testing laboratory certification label[1] for an extruded polystyrene insulation reveals:

Max. 2 inch thickness	**Max. 3 inch thickness**
Max. 2.1 pcf density	**Max. 2.1 pcf density**
Flame Spread 15**	**Flame Spread 15++**
Smoke Developed 140**	**Smoke Developed 140++**

** Flame spread and smoke developed recorded while material remained in original test position. **Ignition of molten residue on the furnace floor resulted in a flame travel equivalent to calculated flame spread classification of 85 and smoke developed classification of over 500.**

++ Flame Spread and Smoke Development recorded while material remained in original test position. **Ignition of molten residue on the furnace floor resulted in a flame travel equivalent to calculated flame spread classification of 125 and smoke developed classification of over 500.**

ASTM E119, Standard Test Method for Fire Tests of Building Construction and Materials, is used to determine the fire resistance of a complete assembly. For example, a wall system fire rating is measured by constructing a 10 foot by 10 foot section of a total wall system: framing, cavity insulation, sheathing, siding, gypsum wall board, etc. The wall section is installed vertically on a gas furnace, and the wall is exposed to a standard temperature curve for the time period for which a rating is desired, i.e., one, two, three, or four hours. Failure points during time of fire exposure are:

- Flame penetration through the wall section
- An unacceptable temperature increase on the unexposed side of the assembly
- Structural failure or collapse of the assembly

Therefore, a one hour fire resistance rating is taken to mean that a structure incorporating the tested wall construction will not collapse, nor transmit flame or a high temperature, while supporting a design load, for at least one hour after a fully developed building fire.

Roof/ceiling and floor/ceiling constructions can also be tested horizontally in accordance with ASTM E119. The building code authorities usually designate the duration of fire resistance needed in a building. Factors affecting the duration resistance include type of construction, occupancy designations, location of the building and insurance criteria.

ASTM E119 is also known as UL 263 or NFPA 251.

Fire Tests For Roof Systems

Many fire tests evaluate performance of complete roof systems, from the roof deck through the roof coverings. These tests measure:

- Resistance of a roof system to external fire exposure
- Roof/Ceiling resistance to an internal fire exposure
- Resistance to interior fire spread
- A roof assembly fuel contribution rate

Many of these tests involve testing the entire roof assembly, while some focus on the individual components.

1 Underwriters Laboratories Inc. Online Classifications Directory

Factory Mutual Roof Tests: FM Calorimeter (FM 4450/4470) and ASTM E108

FM Approvals, established to assess product or material risk and system performance for specific insurance underwriters of property, liability and casualty policies, approves roof assemblies based upon a comprehensive series of tests outlined in FM Standards 4450 and 4470. This series of tests evaluates materials for their ability to resist fire, wind, hail, durability and corrosion of metal parts. Roofing assemblies that successfully pass all tests in Standard 4450 are given an FM Class 1 rating. Other assemblies are rated Class 2.

FM classifies roof decks into two categories:

- Noncombustible Rated
- Class 1 Rated

Noncombustible Rated decks are cementitious decks such as structural concrete, fiber reinforced cement, gypsum and certain lightweight insulating concretes. Class 1 Rated Decks may be steel, fire-retardant-treated wood, cementitious wood fiber, fiber reinforced plastic and certain lightweight insulating concretes.

FM fire performance tests are the FM Calorimeter (FM Standard 4450/4470), which is used to assess the fuel contribution rate of a roof assembly, and ASTM E108, which is used to assess the resistance to external fire exposure. Insulation products are evaluated in roof assemblies for fire performance using the FM Calorimeter, which in turn qualifies them to be included in assemblies meeting FM 4450/4470 standards. ASTM E108 also tests the entire roof assembly and includes the following three parts:

- Spread of flame
- Intermittent flame
- Burning brand

The spread of flame is the only test conducted on roof assemblies with concrete, steel or gypsum decks, while all three tests are performed on assemblies incorporating combustible roof decks (wood, plank, plywood, T&G). The slope of the roof and maximum insulation thickness are both factors as well.

Underwriters Laboratories Inc. Roof Tests: UL 790, ANSI/UL 1256 and UL 263

UUnderwriters Laboratories Inc. (UL) is an independent testing organization established to evaluate products for public safety. UL conducts three basic fire tests for roofing assemblies: Resistance to External Fire Exposure (UL Standard 790, ASTM E108, or UBC 15-2), Resistance to Interior Fire Spread, (ANSI/UL 1256), and Roof/Ceiling Fire Resistance Rating (UL 263, ASTM E119, NFPA 251, or UBC 7-1).

The UL version of ASTM E108 is UL 790. As such, three test procedures are included in UL 790: Spread of Flame, Intermittent Flame, and the Burning Brand. Since this test evaluates the performance of a roof assembly, all components of the roof system are tested together.

With ANSI/UL 1256, the entire roof assembly (deck, adhesives, vapor retarders, insulation, and roof membrane) is tested in a 25 foot long tunnel for 30 minutes. The test uses an open flame with prescribed airflow in the tunnel. Ratings derived from the test are reported in the UL Roofing Materials and Systems Directory under the Roof Deck Constructions category (TGKX).

The UL version of ASTM E119 is UL 263 and is used to evaluate the length of time that a roof assembly can contain a fire or retain structural integrity. Assemblies that pass these tests are granted hourly ratings called P Designs.

Importance of FM 4450 Calorimeter Test and ANSI/UL 1256 Resistance to Interior Fire Spread Test

The spread of fire on the underside of a roof deck is a concern especially when buildings have large, open interior space, such as a warehouse or manufacturing facility. The two fire tests used by code bodies to evaluate the spread of fire in this manner are FM 4450, also called the FM Calorimeter Test, and ANSI/UL 1256, also known as the Resistance to Interior Fire Spread Test. While both tests evaluate the entire roof assembly from deck to roof covering, the test conditions and test pass criteria are very different:

	FM 4450	UL 1256
Exposed Sample Size	4 feet x 4 feet	1.48 feet x 24 feet
Test Duration	30 min.	30 min.
Fuel Source/Rate (Btu/min.)	Heptane/Propane / 26,400	Natural Gas / 5,000
Temperature @ 10 min.	1500 degrees F	580°F (vent and with non-combustible calibration sample)
Temperature @ 30 min.	1600 degrees F	NA
Pass Criteria	No external flaming; no dropping of flaming particles into the furnace	Flame spread @ 10min., less than 10 feet; @ 30 min., less than14 feet; visual examination of thermal degradation and "combustive" damage
Pass Criteria, Maximum Fuel Contribution (Btu/ft2/min.)	3 min. 410 5 min. 390 10 min. 360 30 min. 285 (avg.)	NA

Not all foam plastic insulations perform equally in these tests. Polyiso is a thermoset material and withstands high temperatures which accounts for its successful performance in both FM 4450 Calorimeter and ANSI/UL 1256 testing. Other foam plastic insulations, such as polystyrene, are thermoplastic materials which soften at 165° F and melt at approximately 200° F. These temperatures are reached long before the standard 30 minute fire exposure has ended. Because of the high temperatures reached in the FM 4450 Calorimeter test, polystyrene melts through the seams of the steel deck, spreads fire on the underside of the deck during the test, and liberates flaming particles into the furnace. Accordingly, FM Approvals does not list any Class 1 Roof System approvals for the use of polystyrene insulation in a direct to steel deck application (i.e., without the use of a thermal barrier).

Only roof assemblies that pass FM 4450 may be used in FM insured buildings.

The White House Test

The "White House Test" was developed by FM in the early 1950s as a means to investigate the reason why the roof system contributed to the total loss of the GM factory in Livonia, Michigan. The test consisted of a non-combustible building 100' long, 20' wide, and 10' high with gasoline fired burners at one end and the other end open. Various roof systems were installed and the test ran for 30 minutes. Satisfactory performance was achieved, flaming on the underside of the deck limited to about 70', in one of a series of tests conducted in 1954 and 1955. Data from that series of tests were used by FM to develop the smaller scale FM 4450 Construction Materials Calorimeter. FM 4450 is now used by FM as the primary test for evaluating the combustibility of insulated roof systems installed on steel roof decks.

FM 4880 25’ High Full Scale Corner Test

Not all roof deck systems are easily configured to be evaluated using FM 4450. About 10 years after use of the FM 4450 Calorimeter Test was started, FM developed the FM 4880 25’ High Full Scale Corner Test.

This versatile full scale test is used to evaluate the flame spread potential of insulated roofs, roof panel systems, insulated walls and wall panel systems alone or in combination. The system(s) to be evaluated are installed on a corner structure 25’ high with walls extending 38’ and 50’ from the corner. During the test, 750 pounds of wood pallets are stacked in the corner 1’ from the walls and allowed to burn for the 15 minutes. To pass the test no fire can exit the limits of the structure—beyond the 38’ or the 50’ walls—during the 15 minute test while the pallet fire naturally develops. This test is accepted by various code bodies and insurance rating organizations and can be used by FM in lieu of FM 4450 tests.

Testing Laboratories

Testing polyiso insulation to show conformance with building code requirements is conducted by several nationally recognized testing agencies accredited by ICC or state or local code authorities.

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