PIMA PRODUCT STEWARDSHIP REPORT

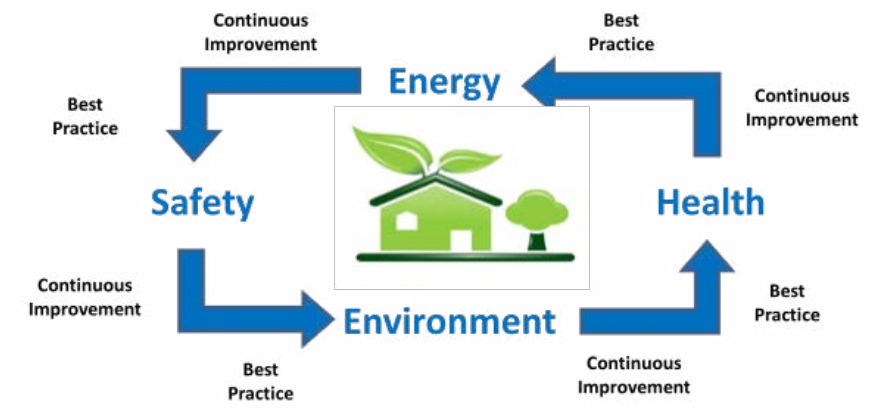
Polyiso Insulation And Flame Retardants

Revised January 20, 2014

PIMA And Product Stewardship

The PIMA Perspective. PIMA and its members are committed to the development of energy-efficient insulation products that make a positive and lasting contribution to the built environment in which we work and live. This commitment extends beyond the basic economics of saving energy and addresses important environmental, health and safety attributes as well. In fact, PIMA and its members view energy, environment, health, and safety as critical and co-equal aspects of product stewardship. When combined with an ongoing commitment to continuous improvement and best practice, this perspective has resulted in a virtuous cycle of product improvement that has established polyiso among the most sustainable building insulation materials available today.

The PIMA Perspective:
A Virtuous Cycle of Continuous Improvement and Best Practice



Tangible Accomplishments. Using the PIMA perspective of continuous improvement and best practice, PIMA's members have constantly reinvented polyiso and the the value proposition it offers. Some of the most notable achievements of this virtuous cycle of product improvement include:

- **Energy.** Offering the highest R-value per unit thickness of any widely-used commercial building insulation, the energy efficiency of polyiso has been optimized though the development of long-

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term measure of thermal resistance (LTTR) that accurately models thermal performance for 15 years or more. In addition, the reliability of LTTR has been reinforced by an industry-leading product quality certification program called QualityMark[CM], which assures reliable and consistent thermal performance for all polyiso insulation products.

- **Environment.** In response to global concerns about the effects of some blowing agents on the world's ozone layer, PIMA and its members successfully implemented a step-by-step reduction in the ozone depletion potential (ODP) of polyiso, culminating in an industry-wide conversion to zero-ODP products. This achievement in continuous product improvement was recognized by the United States Environmental Protection Agency (EPA) with a Stratospheric Ozone Protection Award in 1992. The EPA also recognized the long-term positive effects of polyiso's energy efficiency on global warming with a Climate Protection Award in 1998.
- **Safety.** PIMA members have developed a wide range of safety certifications for polyiso, especially in the area of building fire safety. Beginning with basic flame spread and smoke development ratings to reduce the rate and severity of fire growth, PIMA members have now developed a wide portfolio of fire test ratings which include complex roof, ceiling, and wall assemblies. This broad array of fire ratings provides building professionals with both flexibility and certainty when designing fire-resistant structures.
- **Health.** In response to increased attention to indoor air quality, especially within LEED and similar green building rating systems, PIMA members have received certifications for their products to meet emerging standards for healthy interior building materials, including low chemical emissions and mold resistance.

Foam Plastics and Fire Resistance

All construction materials including foam plastics must provide a suitable margin of fire safety not only after a building is constructed and occupied, but also during construction and even before construction starts. This means that materials stored on the job site as well as materials temporarily exposed during the construction process must provide a significant level of inherent fire resistance separate from their eventual fire performance when fully integrated into the finished building. Because of the need to assure fire safety before and during construction, modern building codes mandate minimum fire performance levels for foam plastics, as measured by small scale qualifying tests. These qualifying tests focus primarily on flame spread and smoke development, which are important to minimize the potential for construction fires to obstruct or endanger building occupants and fire fighters. In addition to assuring a reasonable level of fire resistance before and during construction, these minimum qualifying tests also may help reduce fire dangers in finished buildings in the event critical roof, wall and ceiling barriers have been compromised or improperly installed.

The best-known of these small scale qualifying tests is ASTM E-84, Standard Test Method for Surface Burning Characteristics of Building Materials, which measures the flame spread and smoke development of building materials within an enclosed fire chamber called a Steiner Tunnel. Currently, building codes across the United States require all foam plastics to provide a maximum flame spread rating of 25[1] and a maximum smoke developed rating of 450[2].

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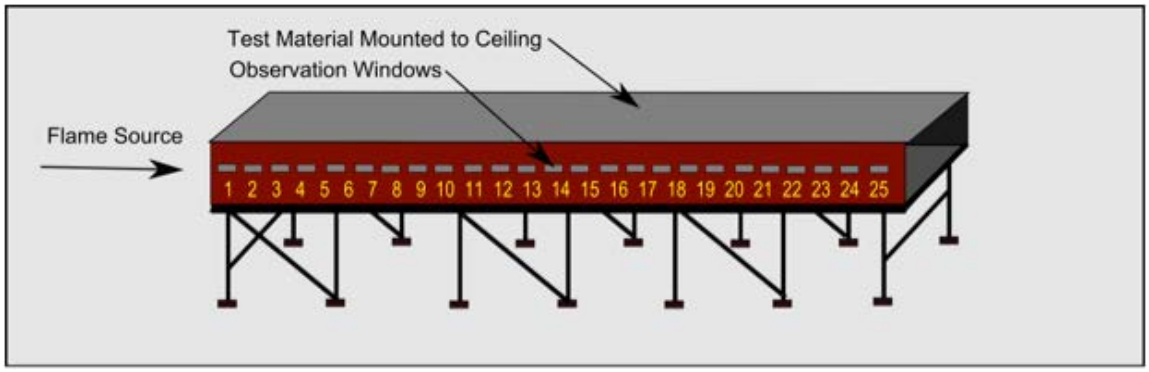

The Steiner Tunnel (ASTM E-84) test consists of a 25' vented tunnel lined with firebrick. The test material is mounted to the top of the chamber. At one end of the chamber, the sample is subjected to a high-energy flame for ten minutes. Flame spread is determined visually through windows built into the tunnel. An optical cell mounted at the tunnel exhaust measures smoke density. (Illustration by TEGNOS Research, Inc.)

Although the ASTM E84 test provides a minimum qualifying criterion for foam plastics, it is only one of a broad array of fire tests that must be applied together to assure overall building fire safety. In addition to small scale E84 testing to establish a base level of fire performance, foam plastics must be subjected to a number of larger scale fire tests conducted on complex roof, wall and ceiling assemblies. Some of the most recognized tests for evaluating building fire safety include:

- UL 790 / ASTM E-108, *Standard Test Methods for Fire Tests of Roof Coverings.*
- NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components.*
- FM / ANSI 4880, *National Standard for Evaluating Insulated Wall and Roof / Ceiling Assemblies.*
- ASTM E-119 / UL 263 / NFPA 251, *Standard Test Methods for Fire Tests of Building Construction and Materials.*

It is important to note that all of these tests employ significantly higher temperatures for a much longer duration than the E84 Steiner Tunnel. In addition, these tests involve a wide variety of building components combined into many different wall, ceiling, or roof assemblies. Because of the rigor and complexity of such tests, basic fire resistive properties of each material within the assembly may play a much more important role in these tests as compared to the simple Steiner Tunnel test of a flame applied to an exposed piece of foam plastic.

In order to meet this broad array of fire tests required by modern building codes, all foam plastics including polyiso currently require the addition of small quantities of flame retardants. Because these flame retardants must be chemically compatible with foam plastics, all fire retardants currently used in foam plastic building insulation are based on organo-phosphate

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compounds. These compounds combine high levels of fire suppression with equally high chemical compatibility with a wide variety of plastic polymers. Currently, these organo-phosphate compounds include:

- HBCD, used in expanded and extruded polystyrene (EPS and XPS)
- TCEP, used in spray polyurethane foam (SPF) and polyurethane foam (PUR)
- TCPP, used in polyiso (sometimes referred to as PIR)

Polyiso And Flame Retardants

Among all foam plastics, polyiso possesses the highest level of inherent fire resistance due to its unique structure of strong isocyanurate chemical bonds. These bonds result in improved high temperature resistance (up to 390°F, more than twice the temperature resistance of other building insulation foams) which in turn leads to enhanced fire resistance. In addition, because polyiso does not melt or drip when exposed to flame but rather forms a protective surface char, its fire resistance is further enhanced, especially in terms of flame spread and flashover potential.

Because of the high level of fire resistance inherent in its isocyanurate structure, polyiso offers flexibility in the selection and amount of additional fire retardants needed to meet the demands of modern fire codes. As a result, the polyiso industry was able to evaluate a variety of suitable plastic flame retardants and choose a product that optimizes both fire and non-fire aspects of product performance. After a thorough review of authoritative global research covering fire safety, health and environmental effects, TCPP was selected by the polyiso industry to provide the additional level of fire resistance required by building codes.

- **Not a Chemical of Concern.** TCPP, or Tris (2-chloro-1-methlyethyl) phosphate, is unique among commonly available foam plastic flame retardants[3] in that it is not classified as a chemical of concern by any authoritative global, national or state authority, including the European Chemicals Agency (ECHA), the U.S. Environmental Protection Agency (EPA), and prominent state authorities such as the California Office of Health Hazard Assessment (OEHHA) and the Massachusetts Toxics Use Reduction Administrative Council (TURA). Based on the best available scientific studies, including a comprehensive risk assessment completed by ECHA in 2008, TCCP is not considered to be toxic or bioaccumulative, and its environmental persistence is lower than other common foam plastic flame retardants.
- **No Environmental Risks.** The 2008 ECHA risk assessment[4], conducted as part of the world-leading REACH program for the registration, evaluation, authorization and restriction of chemical substances, provides exhaustive documentation regarding the environmental performance of TCPP. In regard to environmental risks associated with TCPP, the study found:
  - "No identified risks to the freshwater aquatic and sediment compartments or sewage micro-organisms from local sources associated with any life cycle stage;
  - No identified risks to the soil compartment from local sources associated with any life cycle stage;

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- No identified risks of biotic or abiotic effects on the atmosphere;
- No identified risks of secondary poisoning of predators (including marine predators) from local sources associated with ant life cycle stage;
- No identified risks to the marine aquatic and sediment compartments from local sources associated with any life cycle stage." (ECHA 2008 Summary Risk Assessment, page 7.)

- **No Consumer Health Risks.** In addition to an environmental assessment for TCPP, the ECHA risk assessment also addressed human health risks for TCPP used in a variety of foam plastic consumer applications. In all cases, the ECHA study concluded that there was "no concern" in regard to consumer health risks, based on measured margins of safety (MOS) ranging from a low of 667 to a high of 395,000 times anticipated exposure levels. In the case of foam plastic used in building insulations, the ECHA study concluded that indoor insulation risks were assumed to be so negligible that they were not included in the final risk characterization phase of the study.

  Beyond the 2008 ECHA risk assessment, we believe a recent meta-study conducted by Battelle Memorial Institute[5] provides additional support to the inherent safety of TCPP. After reviewing thirty of the most relevant laboratory and field studies involving TCPP gathered by Battelle, we arrived at conclusions similar to the ECHA risk assessment. In regard to exposure levels and margins of safety, Battelle stated in general, "estimated indoor exposures to TCPP ... are lower than applicable reference doses (RfDs), threshold daily intake (TDI), or to other applicable health-risk based values." And in regard to the potential for latent TCPP or other flame retardants within buildings, the documents that were part of the review revealed that any indoor concentration of TCPP or any other organo-phosphate flame retardant is "not present as a result of building material emissions (e.g., wall insulation) but rather due to releases from furnishings and consumer products."

- **No Need for Further Testing / Risk Reduction at Present.** Based on these detailed findings, the overall conclusion of the 2008 ECHA risk assessment stated:

  "There is at present no need for further information and/or testing (for TCPP) and no need for risk reduction measures beyond those which are being applied already."

Flame Retardant Risk Assessment And The PIMA Perspective

Based on the results of the 2008 ECHA and other risk assessment studies, PIMA and its members are confident that the polyiso industry has selected a suitable flame retardant consistent with its ongoing commitment to continuous improvement and best practice. Because of the high inherent fire resistance of polyiso foam, the polyiso industry was able to evaluate a broad array of suitable fire retardants and select the flame retardant with the most favorable environmental and health risk assessment. And because the risk assessment upon which this decision was based represents the most up-to-date and authoritative global studies for the evaluation of chemical risks, the polyiso industry was able to support its ongoing commitment to product design based on best available global practice.

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PIMA's perspective is based on fundamental principles of continuous improvement and best practices. PIMA and its members recognize that the design and selection of the components and ingredients of polyiso insulation is a never-ending process that always must target higher levels of performance and benefit. It is possible and perhaps likely that as science continues to advance that new flame retardants or fire-resistive processes will be developed that may provide even greater economic, environmental and health benefit. As a result, the polyiso industry will continue to seek out novel product solutions that will continue to expand the value proposition of polyiso insulation as the world's best solution for insulating buildings and residences.

However, until new scientific findings and advances have been established, the polyiso industry and its customers are best-served by the continued use of a product like TCPP as a critical flame retardant. The best support for this position regarding TCPP may be found in the conclusions of a 2010 study conducted by the British Department of Environment, Food and Rural Affairs (DEFRA)[6], which not only supported previous research but also endorsed TCPP as the best available sustainable solution for foam plastic fire resistance:

> "Until (other flame retardant alternatives can be adequately risk-assessed) it would be perverse to exclude a compound like TCPP by over-restrictive … criteria centered on excluding all halogen containing FRs."

PIMA and its members share two common convictions with the British environmental agency. First, we recognize that we can never relent in efforts to improve the performance of our products. But we also recognize that arbitrary exclusion of currently best-available technology may only impede progress and overall improvement of critical building materials such as high-performance polyiso insulation.

This report on polyiso and flame retardants has been prepared by The Polyisocyanurate Insulation Manufacturers Association (PIMA), a national association of polyiso insulation manufacturers and suppliers. PIMA advances the use of polyiso insulation and is one of the nation's leading advocates for energy-efficiency and has been recognized by both the U. S. Environmental Protection Agency and the Sustainable Building Industries Council for advocacy and products that contribute to energy efficiency and combat global warming.

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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:

- Moisture resistance
- 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
- 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 wall systems
- 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."

Polyisocyanurate ("polyiso") is a closed-cell, rigid foam board insulation used on the roofs and walls of commercial buildings and residences. Because of its high thermal performance, it is a product of choice for energy-aware building owners and designers. Polyiso is one of North America's most widely-used and cost-effective insulation products and has been cited by the U.S. Environmental Protection Agency for its responsible impact on the environment. Among its many features, Polyiso insulation offers the highest R-value per inch, backed by third-party thermal performance certification.

Notes:

1. As measured in feet along the E84 Steiner Tunnel.
2. As measured by observation through windows along the E84 Steiner Tunnel.
3. Including HBCD, TCEP and TDCPP which are currently used as flame retardants in a variety of foam plastic applications.
4. Tris (2-Chloro-1-Methlyethyl) Phosphate (TCPP) Full and Summary Risk Assessment Reports. European Chemicals Agency (ECHA), 2008.
5. Potential Exposure to Flame Retardants such as TCPP Emitted from Polyurethane and Polyisocyanurate Foam Insulation: Literature Evaluation Results. Battelle Memorial Institute, 2013. Battelle Memorial Institute (Battelle) does not endorse or recommend particular companies, products, services, technologies, nor does it endorse or recommend financial investments and/or the purchase or sale of securities. BATTELLE MAKES NO WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, FOR ANY REPORT, SERVICE, DATA OR OTHER INFORMATION PROVIDED HEREIN.
6. Fire Retardant Technologies: Safe Products with Optimised Environmental Hazard and Risk Performance. UK Department of Environment, Food and Rural Affairs (DEFRA), 2010.

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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.

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