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Polyurethane and Polyisocyanurate Foams

Energy Efficient

Versatile

High Performance

api
Alliance for the Polyurethanes Industry
A Business Unit of the American Plastics Council

Rigid Polyurethane & Polyisocyanurate Foams: **The Energy Savers**

You're at home with Foam.

Saving energy in buildings becomes more important every day. Energy lost through walls, roofs and windows is the largest single waste of energy in most buildings. Energy loss in buildings means extra operating costs, loss of comfort, and reduced productivity. There is a family of products that helps solve the typical problem of maintaining or improving performance at a reasonable cost. Rigid polyurethane and polyisocyanurate (polyiso) foams are some of the most efficient thermal insulating products for buildings and for improving the efficiency of the building envelope.

Here's why:

Energy Efficiency

Rigid polyurethane (PUR) and polyiso (PIR) foams simply have the highest R-value per inch of all commercially available foam insulation products. With typical values in the range of R 5.6 to R 8 per inch, it is possible to have thinner walls and lower profile roofs yet retain high maximum efficiency. Insulated entry doors, freestanding freezers, and refrigerated storage, all have thinner profiles thanks to rigid polyurethane foam. This allows more freedom for the architect or engineer to maximize the usable space in a building while reducing operating costs. Innovative material design and advancement have resulted in high quality closed cell insulating products that reduce energy loss. In a one-year study, plastic building and construction materials saved 467.2 trillion Btu's of energy over alternative construction materials. The energy saved by using plastic building and construction materials in one year is enough to meet the average annual energy needs of 4.6 million U.S. households. Energy efficiency impacts more than just operating costs. Highly efficient walls and roofs may allow heating and cooling equipment to be downsized. Operating expense and capital cost may be reduced. This may translate into more floor space for the same total price; savings that can be used to pay a mortgage or build a home with more amenities.

High Performance

Most thermal insulation products, because of low density, must be supported or protected by surrounding materials. These insulation materials may be friable, soft, or extremely sensitive to moisture. Not so with PUR and PIR foam insulation products. They are made from a closed cell thermosetting plastic with a strong yet lightweight structure, are dimensionally stable, and moisture resistant. This combination of properties allows manufacturers to design thermal insulating products, can be attached to a wide range of substrates while requiring no additional adhesive, and - when combined with the proper materials - perform as external weather barriers. This high performance combination is unique, encompasses a wide range of manufacturing processes, and results in thermal insulation products with multiple functions. High performance insulation can be spray applied to various substrates or molded to special shapes in relatively large sizes, has a high mechanical strength, which adds strength to lightweight walls or roof decks, and as a roof covering, spray polyurethane foam (SPF) can increase the wind uplift resistance of existing roof coverings such as built-up roofing and metal. PIR sheathing products practically eliminate thermal shorts and allow homeowners to get excellent value from all the insulation in the wall, reducing heating and cooling costs. Structural exterior panels are produced in 3' or 4' widths, and in extended lengths so that buildings can be assembled quickly using a minimum number of trades.

Versatility

For any building element or design goal, there is probably a PUR or PIR product that fits the bill. PIR boardstock is the most widely used insulation in conventional commercial roofs. For special exterior designs, foam core panels offer a wide variety of colors and profiles for walls and roofs. Some PUR foams can be applied on-site to seal gaps and cover irregular shapes. Such foams include spray, pour-in-place, and one-component foams. SPF forms a seamless layer of insulation, fills gaps and seams during application, and covers irregular shapes that are hard to insulate with rigid boards. That can mean no drafts, and stiffer, quieter buildings. For durability and stability, PUR foam cored entry doors and garage doors are available in finishes and styles to suit the most demanding client. Structural insulated panels - foam core insulation with both an exterior and interior facing - can be made part of the structure of a building. Facing materials include gypsum, engineered wood or natural wood products. These insulated panels, manufactured in a controlled environment, improve product quality, speed erection of buildings, and reduce the amount of wood necessary for the structural framing.

Thermal/Mechanical Performance

PUR and PIR foams have the highest insulating values of any conventional foam insulation commercially available today. By its nature, thermal insulation must be low in density. This means it reduces energy transfer: less material generally means less solid conduction. Very low conductivity gases trapped in the closed cell structure also reduce heat transfer by conduction, thereby further increasing the thermal efficiency of these foams. The small cell size practically eliminates convection, another source of energy transfer. Every cell wall acts as a barrier to energy transmission by radiative heat transfer. The package of these properties comes with a material that can be used in service between –100° F to 200° F, is moisture resistant, dimensionally stable, air tight, resistant to the transfer of heat through the building envelope, and often performs a structural role.

PUR and PIR foams function in temperature extremes, do not deform or distort, and are not subject to damage by the moisture that may result from condensation. In addition, the mechanical strength of these foams is remarkable. High compressive and shear strengths allow low density insulating cores to be faced with relatively thin steel or aluminum and yet span long distances unsupported. For example, the foam can hold together many of the components in a refrigerator or hot water heater while it continues to perform as thermal insulation. This unique combination of properties allows PUR foams to be used in many diverse applications.

Environmental

Every component that foam replaces, every time it reduces the weight of a finished product, and every time a designer exceeds minimum thermal insulation requirements in a cost effective way, results in an environmental benefit. Better insulation typically results in less energy use. Less complicated and lighter weight products are usually produced using fewer manufacturing steps, less energy in manufacturing, and less energy in transportation. The energy conservation achieved by insulating and sealing a building effectively helps to reduce CO_2 emissions associated with the burning of fossil fuels. For all these reasons, PUR and PIR foams can contribute to the creation of a more sustainable society and culture by conserving resources today.

Applications/Products Chart

Applications	Products	Association
Commercial roofing	Laminate boardstock	PIMA
Commercial roofing	Spray foam	SPFA
Commercial roofing	Architectural panels	MCA
Residential sheathing	Laminate boardstock	PIMA
Door & wall panel cores, Some refrigeration	Bunstock	API
Cavity wall insulation	Spray foam	SPFA
Sealant foams, 1-component, 2-component	Spray foam	SPFA
Building envelope insulation	Spray foam	SPFA
Curtain wall	Architectural panels	MCA
Cold storage building - Freezers, Coolers	Architectural panels	MCA
Commercial refrigeration	Foam-in-place	CRMA
Post and beam construction	Structural insulated panels	SIPA
SIP construction panels	Structural insulated panels	SIPA
Tank and pipe insulation	Molded foam	API
Household refrigerators and freezers	Pour-in-place	AHAM
Water heater insulation	Pour-in-place	API
Entry doors	Pour-in-place	ISDI
Garage doors	Pour-in-place	API
Spas, tubs, showers	Spray foam	SPFA
Air barrier systems	Spray foam	SPFA
Exterior wall insulation - Commercial/Residential	Spray foam	SPFA

Products

Rigid polyurethane and polyiso foams are produced from the reaction of specially formulated recipes tailored to specific manufacturing techniques. The speed of the reaction may be adjusted from very fast for SPF - complete in a matter of seconds - to perhaps a minute or so for molding large walk-in cooler panels. This freedom of choice allows for a wide variety of production processes and results in finished products suited to particular applications. The main processes/products are described here.

Polyisocyanurate Laminate Foam

Manufacturing Process

During the manufacturing process the liquid foam forming ingredients are mixed and deposited on a continuously moving lower facing. An exothermic chemical reaction causes the mixture to expand and come into contact with and adhere to the upper facing. Facing materials may be plain or reinforced aluminum foil, fiberglass-reinforced cellulosic felt, all glass facers, or rigid boards.

Performance

Polyiso laminate foams are one of the most popular insulating board products in construction; thermoset materials, they are resistant to molten asphalt and common construction adhesives. These properties make them the most commonly used insulation for commercial and industrial low slope roofs. The variety of facing materials available allows compatibility with practically all types of waterproofing membranes and eliminates the need for special protection or separation layers that must be used with some other products. Residential insulated sheathing is also a popular use for these insulating boards. Foil faced boards, typically 1/2" to 1" thick are applied directly to braced framing, the joints taped, and then covered with exterior siding. Conventional fibrous insulation or SPF is used in the wall cavity. The polyiso "thermal blanket" insulates the framing materials, substantially improving the overall R-value and reduces the possibility of moisture condensation in the wall cavity.

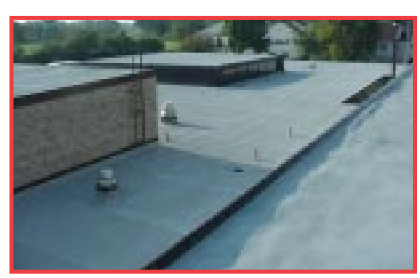
Application

Laminate foams are used as insulation in commercial and industrial low slope roofs, residential insulated sheathing, core materials for structural insulated panels, and in other specialty applications such as solar collectors.

Spray Polyurethane Foam

Manufacturing Process

Spray foams are produced from a mixture of very fast reacting foam forming ingredients combined in a special mixing spray gun at the moment of application. Foam density can be varied in the recipe to suit particular applications and may be applied to almost any substrate that is clean, dry, and free of scale or dust. The rapid reaction achieves full rise and a tack-free surface in a matter of seconds and also acts as a sealant. The foam may be protected with another coating, such as an ignition or weather barrier.



Performance

SPF is most commonly used as insulation in wall and ceiling applications, roofing systems and air barrier applications. SPF conforms to unusual configurations, has no seams or joints, which eliminates thermal bridging, stops air infiltration, prevents drafts and heat leaks while providing seamless insulation value. It has a high strength to weight ratio and tenacious adhesion to a wide variety of substrates that enables it to increase the racking strength of wall assemblies and provide exceptional wind uplift resistance in roofing systems. When used in roofing applications, SPF typically can be installed over many types of existing roof coverings thereby eliminating the need for costly tear-off and replacement.

Application

SPF is most commonly used as roof insulation, or industrial process insulation. However, it is an extremely versatile material that has also been used to create movie and stage sets and other decorative effects.

Pour-in-Place Foams

Manufacturing Process

A characteristic of PUR and PIR foams is that they are produced from liquid ingredients that expand and harden to cure. Products can be molded to specific shapes, foam can be used to fill and insulate irregular shaped cavities, or the foam can be produced in large "buns" which are later cut or formed into the desired final shape. Hence, the term "pour-in-place" is applied to this type of production process.

Performance

Pour-in-place foams are used for a variety of applications such as cavity-wall insulation, water heaters, refrigerated trucks and refrigeration appliances. Its use in domestic refrigerators and freezers is perhaps the most common use. Just a few decades ago refrigerators had thick steel exterior and interior walls. Today, the walls are very thin; the exterior is made of light-gauge metal; interior walls are typically plastic. What gives the cabinet its rigidity and its high insulation value is polyurethane foam. The foam not only functions as insulation, but literally holds the cabinet together. It also enables the manufacturer to produce a high quality cabinet more efficiently, which translates into greater consumer value.

The same characteristics that make domestic refrigerators more efficient also have benefits for walk-in-coolers, soft drink vending machines, and chilled grocery display cases. Most of the cold storage facilities that freeze, chill, store and preserve fresh foods are made from panels produced with rigid polyurethane foams, and that includes the trucks that transport the products to our neighborhood markets.

Application

Pour-in-place foams are used in a wide variety of products. They are used to produce insulated panels with many different kinds of facing materials, insulated exterior entry doors, insulated wall and roofing panels, refrigerated cases for grocery and convenience stores, refrigerated soft drink vending machines, home appliances, domestic hot water heaters, and even decorative items for furniture and signs. Pour-in-place foam may also be used for marine flotation.

Foam Composite Panels

Manufacturing Process

The facing material, typically pre-coated or painted steel or aluminum, is delivered as large flat rolls or coils to the panel-producing factory and then formed in-line. These profiles can be modified so that one plant can produce several different styles and colors of foam-insulated panel. A foam forming mixture is applied between the top and bottom facings where it hardens and bonds the facers together. Panels are cut to length and packaged to protect the painted surfaces.

Performance

Foam composite panels are used as insulated roof and wall panels for conventional or special temperature controlled environments. These structural panels provide the ability to quickly erect complete buildings in a short period of time with a limited number of trades. Panels are manufactured with a wide variety of facing profiles, colors, and textures to create buildings that are very energy efficient. Highly designed edge details practically eliminate thermal shorts and provide sealing technology to do away with problems of air or water infiltration. Because the panels are light in weight the supporting structure can also be simpler and faster to assemble. These foam composite panels can be erected at any time of year: common weather-related construction delays are reduced or eliminated. The benefit is a custom building that is tailored to a customer's needs but very cost effective and visually appealing.

Application

Foam composite panels are used as insulated roof and wall panels for conventional or special temperature controlled environments. A similar process may be used for garage door panels.

Manufacturing Process

PUR foams are produced by an exothermic chemical reaction between liquid polyol and polymeric isocyanate. During the manufacturing process the liquid foam forming recipe (polyol, catalysts, surfactants, blowing agents, and other ingredients) are usually premixed in isolated, temperature controlled tanks and then mixed in very specific and highly controlled weight ratio with polymeric isocyanate to initiate the chemical reaction. Depending on the type of application the remaining processes are specifically designed for the ultimate finished product.

For polyiso laminates the foam mixture is deposited on a continuously moving lower facing. The mixture expands, forming a cellular foam, because the heat generated by the chemical reaction causes the "blowing agent" to change from a liquid to a gas. As it is expanding, the upper facing is brought into contact with the rising foam. The chemical reaction causes the foam to turn from liquid to solid, and the "blowing agent" becomes trapped within the cells of the foam. Facing materials may be plain or reinforced aluminum foil, fiberglass-reinforced cellulosic felt, or fiberglass paper. Composites may be produced with rigid board facings (gypsum, wood panels, fiberboard) on one side and roll facings on the other. The chemicals used to produce polyiso foam are remarkable adhesives so no additional adhesive material is necessary to attach the facing materials.

SPF components ('A' side and 'B' side) are pre-blended separately and packaged in drums for delivery to the jobsite, where they are usually stored in a temperature-controlled environment. The two components are pumped in metered proportions through separate heated hoses to a portable mixing unit (spray gun) where the foam is applied to the substrate as a fine spray. Foam density can be varied in the recipe to suit particular applications. The foam reacts extremely rapidly, achieving full rise and a tack-free surface in a matter of seconds.

Foam cored insulated panel facing materials, typically pre-coated or painted steel or aluminum, are delivered as large rolls or coils of pre-finished metal to the panel-producing factory. To improve the stiffness of the completed panel these facing materials are then formed into profiles (roll formed) and fed to the foam forming and laminating section of the process. The foam forming ingredients, pre-prepared and temperature conditioned, are deposited evenly on the lower facing. The upper facing, also profiled in a prior step, is positioned over the lower facing and all three components enter a heated conveyor/press. Because of the special face and edge profiles, the conveyor surfaces are specially formed to mold or match the panel cross-section. After curing in the conveyor/press, the finished panel enters the saw section where the panels are cut to the proper length using computer-controlled equipment. Careful handling of the panels through all steps is important to maintain the aesthetic surfaces to avoid damaging the automatically applied caulks and seals.

A characteristic of PUR and PIR foams is that they are produced from liquid ingredients that expand and harden to cure. Products can be molded to specific shapes, the foam can be used to fill and insulate irregular shaped cavities, or the foam can be produced in large "buns" which are later cut or formed into the desired final shape. Hence, the term "pour-in-place" is applied to this type of production process. As in the other processes the pre-blended liquid ingredients are stored and delivered to the mixing device after temperature conditioning. The liquid foam forming mix is delivered to a closed mold or open cavity where it expands, filling the cavity, and hardens in the same shape as the mold cavity. The mold cavity may be a rectangular solid shape such as a panel, or it may be a replica, which duplicates the detail of a woodcarving. In either case the mold surface may be prepared with another material to which the foam will adhere (metal, wood, gypsum board, etc.) or may be treated with a release agent so that the foam shape can have surface finishes applied in a separate step.

Fire Safety

- As with other organic materials used in construction, PUR foams must meet certain building code standards. As such, PUR foams must be protected from accidental ignition.
- PUR/PIR foam must have a smoke developed rating no greater than 450 (except for roofing) and a flame spread rating no greater than 75* when tested according to ASTM E-84.
- PUR/PIR foam may be used to insulate interior walls and ceilings when protected by a code approved thermal barrier (gypsum wallboard or the equivalent,) unless specific code approved fire testing demonstrates such barriers are not needed.
- PUR/PIR foam may be used up to 10” thick for cold storage rooms when covered by a code approved thermal barrier and protected by sprinklers.
- All spray foam insulations should be covered the same day they are installed.
- Architectural panels with a foam core (max. 4” thick) having a flame spread no greater than 25* (ASTM E-84) and faced with specified thicknesses of aluminum or steel may be used if protected by sprinklers.
- PUR/PIR foam may be used as a component of A, B or C roofing assembly and on other specific cases.
- PUR/PIR foam plastics not meeting the above requirements may be individually approved on the basis of building code accepted tests such as FM 4880, UL Std. 1040, or UL Std. 1715.

For more information on fire safety issues associated with polyurethane, contact the Alliance for the Polyurethanes Industry at (703) 741-5656 and ask for publication #AX-240 “PU Products: Guidelines to US Model Building Code Fire Performance Requirements” or visit the literature section of the website at www.polyurethane.org.

Other Considerations

- Requires precautions to prevent accidental ignition of exposed foam during construction.

Weather Resistance

- Needs protection from sunlight and other weather conditions for exterior applications.
- Sustains physical property deterioration when continuously exposed to temperatures greater than 200° F.

Building Environment

- A vapor barrier is recommended between any insulation material and the warm side of the building. Because these products perform so well in sealing buildings, it is important to provide for adequate air exchange in the building design.

* These numerical, flame spread ratings are not intended to reflect hazards presented by this or any other material under actual fire conditions.

This summary is a general guideline. For specific applications, consult your product manufacturer, installer, applicator or state and local code officials. Certain buildings housing swimming pools, cold storage or high moisture occupancies generating acute moisture drives require special attention to vapor barriers.

Association Contacts

Alliance for the Polyurethanes Industry (API)
1300 Wilson Boulevard
Arlington, VA 22209
Telephone: (703) 741-5656
Fax: (703) 741-5655
www.polyurethane.org

Association of Home Appliance Manufacturers (AHAM)
1111 19th Street NW, Suite 402
Washington, DC 20036
Telephone: (202) 872-5955
Fax: (202) 872-9354
www.aham.org

Commercial Refrigerator Manufacturers Association (CRMA)
4100 North Fairfax Drive, Suite 200
Arlington, VA 22203
Telephone: (703) 524-8800
Fax: (703) 528-3816
www.ari.org/crm

Insulated Steel Door Institute (ISDI)
30200 Detroit Road
Cleveland, OH 44145
Telephone: (440) 899-0010
Fax: (440) 892-1404
www.wherryassoc.com/isdi.org

Metal Construction Association (MCA)
4700 W. Lake Avenue
Glenview, IL 60025
Telephone: (847) 375-3675
Fax: (877) 665-2234
www.mca1.org

Polyisocyanurate Insulation Manufacturers Association (PIMA)
515 King Street, Suite 420
Alexandria, VA 22314
Telephone: (703) 684-1136
Fax: (703) 684-6048
www.pima.org

Spray Polyurethane Foam Alliance (SPFA)
4400 Fair Lakes Court, Suite 105
Fairfax, VA 22033
Telephone: (800) 523-6154
Fax: (703) 222-5816
www.sprayfoam.org

Structural Insulated Panel Association (SIPA)
3413 A 56th Street
Gig Harbor, WA 98335
Telephone: (253) 858-SIPA
Fax: (253) 858-0272
www.sips.org

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A BUSINESS UNIT OF THE AMERICAN PLASTICS COUNCIL

1300 Wilson Boulevard
Arlington, VA 22209-2321

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