Polyurethane and Polyisocyanurate Foams

Insulation that Works

Energy Efficient, Versatile, and High Performance

American Chemistry Council | Center for the Polyurethanes Industry

Rigid Polyurethane & Polyisocyanurate Foams:

Ways to Save on Energy Usage

You're at Home with Foam.

Saving energy in buildings becomes more important every day. Today, nearly 40 percent of our nation's energy is used to heat, cool and operate our homes and buildings. 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. When it comes to energy efficiency in buildings, why are plastic-based products such as rigid polyurethane foam (PUR), spray polyurethane foam, and polyisocyanurate foam insulation (PIR or polyiso) at the center of the discussion? It's because they are some of the most efficient thermal insulating products for buildings. They work to reduce heating and cooling loss, improving the efficiency of the building envelope.

Energy Efficient

Insulation performance is typically measured by R-value, or thermal resistance. The higher the R-value, the better the material insulates against heat transfer. PUR and PIR foams have some of the highest R-values per inch of all commercially available insulation products. With typical R-values in the range of R 3.6 to R 7.2 per inch, polyurethane products allow for energy efficient designs featuring thin walls and low profile roofs. This allows the architect or engineer to maximize the usable space in a building while reducing operating costs.

Innovative material design and technology advancements have resulted in high quality polyurethane insulation products that reduce energy loss. In a one-year study by Franklin Associates, 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. In fact, the U.S Environmental Protection Agency estimates that homeowners who air seal and insulate their homes can save up to 20% of heating and cooling costs. Energy efficiency impacts more than just operating costs. Highly efficient walls and roofs may allow heating and cooling equipment to be downsized by as much as 35 percent. This may translate into more floor space for the same total price.

High Performance

Traditional fibrous insulation products must be supported or protected by surrounding materials because of their low density. These insulation materials may be soft or sensitive to moisture, which is not the case for polyurethane insulation products. Polyurethane foam is a thermosetting insulation, providing structural performance and fire resistance. Polyurethane products have a strong yet lightweight structure, are dimensionally stable, moisture resistant and durable. This combination of properties allows manufacturers to design polyurethane thermal insulating products for many diverse applications and allows it to be attached to a wide range of substrates. In addition, when combined with the proper materials, they can perform as external air barriers, helping prevent the infiltration of outside air and the escape of indoor air.

For any building element or design goal, there is probably a polyurethane product that fits the need.

This high performance combination is unique, encompasses a wide range of manufacturing processes, and results in thermal insulation products with multiple functions. For example, spray polyurethane foam (SPF) insulation products can be spray applied to various substrates and others can be molded to special shapes in relatively large sizes. High-density SPF has a high mechanical strength that can add strength to lightweight walls or roof decks. As a roof covering, high-density SPF can increase the wind uplift resistance of existing roof coverings. PIR sheathing products practically eliminate thermal shorts and allow homeowners to get excellent value from all the insulation in the wall, which can reduce heating and cooling costs. Structural Insulating Panels (SIPS) are pre-manufactured in a variety of sizes, allowing for quick on-site assembly into a building using a minimum number of workers.

Versatility

For any building element or design goal, there is probably a polyurethane product that fits the need. PIR boardstock is the most widely used insulation in conventional commercial roofs. For special exterior designs, Insulated Metal Panels (IMPS) offer a wide variety of colors and profiles for walls and roofs. Some foams can be applied on-site to seal gaps and cover irregular shapes. Such foams include spray, pour-in-place, and one-component foams. Spray foam forms a seamless layer of insulation, fills gaps and cracks during application, and covers irregular shapes that are hard to insulate. That can mean no drafts, and stronger, quieter buildings. For thermal resistance, 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. These insulated panels, manufactured in a controlled environment, can improve product quality, speed of erecting buildings, and reduce the amount of wood necessary for the structural framing.

Thermal/Mechanical Performance

Polyurethane foams have some of the highest insulating values of any conventional foam insulation commercially available today. They contain very low conductivity gases trapped in a closed-cellular structure, which reduces heat transfer by conduction. The small cell size practically eliminates heat transfer by convection, another source of energy transfer. Polyurethane foams can be used in a wide range of service temperatures, generally from -100°F to 200°F.

The mechanical strength of polyurethane 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 polyurethane foams to be used in many diverse applications.

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Environmental Considerations

Foam can provide environmental benefits in a variety of ways – from providing superior insulating properties, to reducing the weight of finished products, to giving designers materials with which they can exceed minimum thermal insulation requirements in cost effective ways. 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 greenhouse gas emissions associated with the burning of fossil fuels to generate electricity. In fact, according to McKinsey and Company, foam plastic insulation products save up to 233 times the carbon dioxide emissions over their useful life, compared to the amount of emissions generated to manufacture and install them. For all these reasons, polyurethane foams can contribute to the creation of a more sustainable society by helping to conserve resources today.

Applications/Products Chart

Applications	Products
COMMERCIAL BUILDING ENVELOPE	
Commercial Roofing	Polyisocyanurate foam
Commercial Roofing	Spray Polyurethane Foam
Commercial Roofing	Insulated Metal Panels
Building Envelope Insulation	Spray Polyurethane Foam
Post and Beam Construction	Structural Insulated Panels
SIP Construction Panels	Structural Insulated Panels
Air Barrier Systems	Spray Polyurethane Foam
Exterior Wall Insulation	Spray Polyurethane Foam, Polyiso Sheathing
Sealant Foams, 1-component, 2-component	Spray Polyurethane Foam
RESIDENTIAL BUILDING ENVELOPE	
Residential Sheathing	Polyiso sheathing
Cavity Wall Insulation	Spray Polyurethane Foam
Sealant Foams, 1-component, 2-component	Spray Polyurethane Foam
OTHER APPLICATIONS	
Door & Wall Panel Cores, Some Refrigeration	Pour-in-place, Bunstock
Cold Storage Building – Freezers, Coolers	Insulated Metal Panels
Commercial Refrigeration	Pour-in-Place
Tank and Pipe Insulation	Molded Foam
Household Refrigerators and Freezers	Pour-in-Place
Water Heater Insulation	Pour-in-Place
Entry Doors	Pour-in-Place
Garage Doors	Pour-in-Place
Spas, Tubs, Showers	Spray Polyurethane Foam

Polyurethane Insulation Products

Polyurethane foams are produced from the reaction of specially formulated diisocyanates with polyols and other chemicals tailored to specific manufacturing techniques. The speed of the reaction may be adjusted from very fast for spray foam, which foams in a matter of seconds, to a reaction taking 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 process and products are described here.

Polyisocyanurate Laminate Foam (PIR or Polyiso)

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

Polyisocyanurate foams are one of the most popular insulating board products in construction. They are thermoset plastics – which form a char in fire conditions rather than melt to form a liquid. They are resistant to molten asphalt and common construction adhesives, making them compatible with traditional commercial roofing systems. These properties make them one of the most commonly used insulation types for commercial and industrial low slope roofs. The variety of facing materials are compatible with practically all types of waterproofing membranes, eliminating the need for special protection or separation layers that are required when using other products. PIR insulation boards are also used in residential sheathing applications. Foil faced boards, typically ½ in to 1 in thick are applied directly to braced framing, the joints taped, and then covered with exterior siding. Conventional fibrous insulation or spray foam is used in the wall cavity. The PIR "thermal blanket" insulates the framing materials, substantially improving the overall R-value of the building envelope, and reducing the possibility of moisture condensation in the wall cavity.

Application

PIR laminate foams are used as insulation in commercial and industrial low slope roofs. PIR sheathing is used to insulate residential and commercial walls, and PIR foam can be used as the core material for structural insulated panels, and in other specialty applications such as solar collectors.

Spray Polyurethane Foam (SPF)

Manufacturing Process

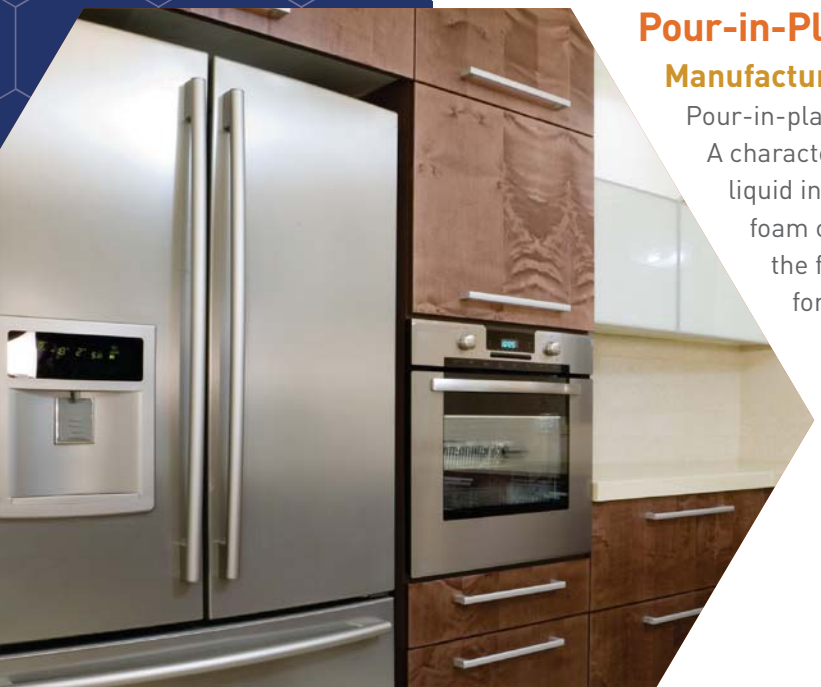
Spray polyurethane foam is produced from a mixture of very fast reacting foam forming ingredients combined in a special mixing spray gun at the moment of application. Foam density can be varied to suit particular applications and may be applied to almost any substrate that is clean, dry, and free of scale or dust. The reaction quickly achieves full rise and a tack-free surface 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 attics, wall and ceiling applications, roofing systems and air barrier applications. SPF conforms to unusual configurations and has no seams or joints, which eliminates thermal bridging, helps stop air infiltration, and limits drafts and heat leaks. It has a high strength to weight ratio and strong 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

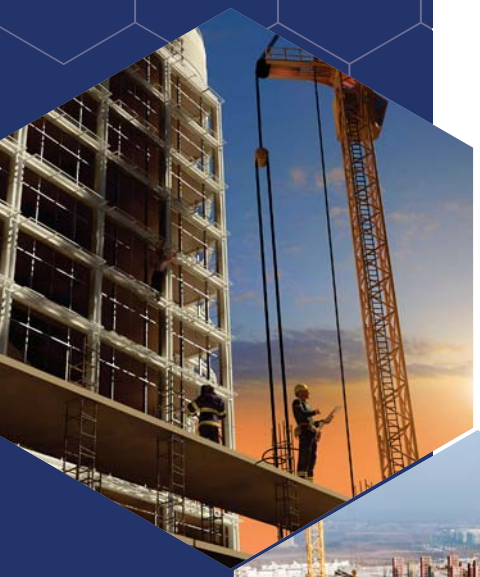
Because it is sprayed directly into the gaps, cracks and other surfaces that contribute to heat loss, it both insulates and air seals, offering one of the easiest and most effective ways of weatherizing existing homes and new construction.



Pour-in-Place Foams

Manufacturing Process

Pour-in-place foam can be molded or poured into specific shapes. A characteristic of polyurethane foams is that they are produced from liquid ingredients that expand and harden to cure. Pour-in-place foam can be used to fill and insulate irregular shaped cavities, and the foam can be produced in large "buns" which are later cut or formed into the desired final shape.



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. 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 and 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 can translate into greater consumer value.

The same characteristics that make 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 trucks that transport the products to neighborhood markets.

Application

Pour-in-place foams are used in a wide variety of products. They are also used to produce insulated panels with many different kinds of facing materials, e.g. insulated exterior entry doors, insulated wall and roofing panels and even decorative items for furniture and signs.

Insulated Metal 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 metal faces together. Panels are cut to length and packaged to protect the painted surfaces.

Performance

These structural panels provide the ability to quickly erect complete buildings in a short period of time with a limited number of workers. Highly designed edge details practically eliminate thermal shorts and provide sealing technology to help eliminate problems of air or water infiltration. Because the panels are light in weight the supporting structure can also be simpler and faster to assemble. Insulated Metal

Panels can be erected at any time of year, reducing or eliminating common weather-related construction delays. The benefit is a custom, cost-effective and visually appealing building that is tailored to a customer's needs.

Application

Insulated Metal Panels are used as insulated roof and wall panels for conventional or special temperature controlled environments. A similar process is used for garage door panels.

Fire Safety

- As with other organic materials used in construction, polyurethane foams must meet certain building code standards. As such, protect these foams from accidental ignition.
- The International Building Code and the International Residential Code require polyurethane foams to 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.

For more information on fire safety issues associated with polyurethane, see the Center for the Polyurethanes Industry's publication "Polyurethane Products: Overview of U.S. Model Building Code Fire Performance Requirements" at http://www.polyurethane.org/s_api/sec.asp?CID=1649&DID=11361.

Other Flammability Considerations

- Exposed polyurethane foam during construction requires precautions to prevent accidental ignition.

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

- Because these products perform so well in sealing buildings, it is important to provide for adequate ventilation in the building design to avoid indoor air quality issues.

*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 require special attention to vapor barriers.

Association Contacts

Center for the Polyurethanes Industry (CPI)

700 2nd Street, NE
Washington, DC 20002
Telephone: (202) 249-7000
www.americanchemistry.com/polyurethane

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

Air Conditioning and Refrigeration Institute (AHRI)
2111 Wilson Blvd, Suite 500
Arlington, VA 22201
Telephone: (703) 524-8800
http://www.ahrinet.org

Metal Construction Association (MCA)
4700 W. Lake Avenue
Glenview, IL 60025
Telephone: (847) 375-4718
www.mca1.org

Polyisocyanurate Insulation Manufacturers Association (PIMA)
7315 Wisconsin Avenue, Suite 400E
Bethesda, MD 20814
Telephone: (301) 654-0000
www.pima.org

Spray Foam Coalition (SFC)
700 Second Street, NE
Washington, DC 20002
Telephone: (202) 249-7000
www.whysprayfoam.com

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

Structural Insulated Panel Association (SIPA)
PO Box 1699
Gig Harbor, WA 98335
Telephone: (253) 858-7472
www.sips.org

American Chemistry Council | Center for the Polyurethanes Industry

700 2nd Street NE • Washington, District of Columbia 20002-4308

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