XEMAX

HUNTSMAN

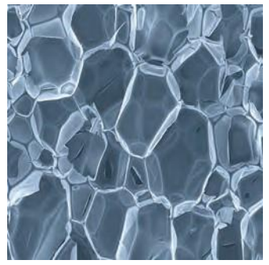
Enriching lives through innovation

Polyurethane insulation for energy efficient, green buildings

What is polyurethane insulation?

Polyurethane insulation is used in many residential and commercial buildings in the US. It is typically made by reacting an isocyanate, such as Huntsman's methyl diphenyl diisocyanate (MDI) with a polyol blend. During the polymerization reaction, a blowing agent expands the reacting mixture. The finished product is a solid, cellular polymer with a high thermal resistance.

Polyurethane insulation comes in open or closed cell form, in varying densities. It is typically installed as insulation on the roofs, walls, floors and ceilings of new and retrofit buildings. It is also used to insulate appliances, pipes and a variety of other products.



Global polyurethanes supplier

Huntsman is a large, global diversified chemical company with about 12,000 employees globally, and annual revenue of approximately $8B in 2009. The Polyurethanes division of Huntsman is a global leader in the manufacture of MDI-based polyurethane systems for energy saving insulation products. With over 45 years experience of serving the construction industry. Huntsman provides innovative solutions to more than 2,000 customers in over 90 countries around the world.

Consistent and reliable supply across the world

Huntsman has three world scale MDI production facilities, in America, Europe and China and a highly capable downstream 'systems' network, which enables the business to supply customers with consistent products, to global specifications, anywhere in the world.

Polyurethanes

making a difference in construction

The versatility of rigid polyurethane foam makes it suitable for an extensive range of insulation applications. Up to 1.5 billion pounds of rigid foam is used each year to reduce energy usage in construction applications e.g. residential and commercial roofs, walls, panels and doors, and in appliance applications (Source: IAL Consultants – 2008 End Use Market Survey).

Polyurethane insulation is a sustainable material delivering real benefits to society facing escalating energy costs, diminishing fossil fuels and the negative environmental effects of climate change.

The most popular applications of polyurethane foam-based insulation are:

- **Insulation Board and Block –** two distinct products offering similar benefits. Insulation board is made of a polyurethane foam core which can be faced with a wide variety of materials including paper, aluminum, kraft, fiberglass, gypsum, perlite, oriented strand board (OSB) and fiberboard. Block is polyurethane foam which can be cut and shaped to the required dimensions. Both are used for a broad range of applications including cavity walls, flooring and roofing.
- **Insulated Metal Panels –** factory engineered exterior panels comprising of metal skins containing polyurethane foam core. Used for roofing and wall cladding.
- **Spray Polyurethane Foam (SPF) and One–Component Foam (OCF)**
  SPF is manufactured on-site by mixing and spraying reacting urethane chemicals onto the substrate. The spray foam expands to seal all cracks and crevices, providing a seamless air barrier. OCF is generally applied using small volume, pressurized containers. It is used to seal doors and windows in construction.
- **Pipe Insulation –** polyurethane foam used to insulate and protect heating and plumbing services within large diameter pipe systems. Typically used in municipal heating and offshore oil and gas pipelines.
- **Pour-in-Place Insulation –** a term used to categorize a wide range of insulation applications, including entry and garage doors, refrigerators, reefers, storage tanks, marine and mining applications.

Features and benefits
of polyurethane foam insulation

Polyurethane foam insulations qualities allow it to be used in many building types where the need for insulation and air-tightness is combined with a requirement for load-bearing, impact resistance, sealing, weight and space optimization, low maintenance and durability.

High Thermal Resistance
Rigid polyurethane foam is widely known for its excellent R-value, which is among the highest of any insulating material. This ensures efficient heat retention or alternatively, consistent temperature control of refrigerated or frozen environments. About half the energy used in the life of a building is for heating and cooling (Source: Energystar), so effective insulation is a major priority.

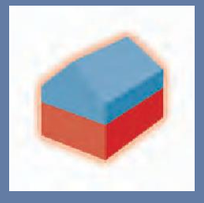
According to the US Department of Energy, "residential and commercial buildings consume 40 percent of the energy and represent 40 percent of the carbon emissions in the United States. Building efficiency represents one of the easiest, most immediate and most cost effective ways to reduce carbon emissions."

Airtightness
Air infiltration can account for 30% or more of a homes heating and cooling costs (Source: US Department of Energy). PU insulation is stable and durable through the life of a building and does not settle and sag to reveal air gaps – unlike fibrous insulation products. Due to its closed cell nature, PU insulation performs as an air barrier, resulting in significant energy savings.

Strength
When polyurethane is bonded to facing materials e.g. plywood, OSB, metal or gypsum wallboard, high levels of both shear and compressive strength are achieved.

Processability
Rigid polyurethane foam can be factory-produced in continuous block or batch form, or it can be produced on-site in spray and injection applications.

Adhesion
During the curing stage, rigid polyurethane foam is highly adhesive, allowing it to bond with many building facing materials. Bond strength is often higher than the tensile or shear strength of the foam. The adhesive strength of PU contributes significantly to an increase in the wind-uplift performance of a roof.



About half of the energy used in the life of a building is for heating and cooling, so effective insulation is a major priority.

Buildings are responsible for 39% of US carbon dioxide emissions.

Source: 2007 Buildings Data Book

"Moisture poses the greatest threat to structural integrity and durability, accounting for up to 89% of damage in building envelopes."

M.T. Bomberg and W.C. Brown, Construction Canada, 35(1), 1993

Compatibility
Rigid polyurethane foam is compatible with a majority of building facings including paper, fiberglass, aluminum, plywood, OSB, gypsum sheathing and foil. The many combinations available add to the inherent strength of the foam, allowing use in semi-structural panels and cladding.

In-situ stability
Extreme temperature ranges of – 328°F to +212°F can be tolerated by rigid polyurethane based foam products.

Water vapor transmission
Rigid polyurethane foam has low water vapor permeability. Polyurethane foam products with a facing such as aluminum foil or polyethylene film, will perform as a vapor barrier preventing mold growth.

Lightweight
At low densities of about 2 lb/ft^3, rigid polyurethane foam is made up of about 97% gas trapped in cells, and just 3% polyurethane polymer. The lightness of the material means reduced transportation costs and easy on-site handling and installation.

Chemical resistance
Rigid polyurethane foam provides excellent resistance to many common chemicals, solvents and oils.

Fire performance
Like all organic building materials (wood, paper, plastics, paints etc.), rigid polyurethane foam is combustible, although its ignitability and rate of burning can be modified to suit a variety of building applications. Local building codes must be consulted for guidelines on acceptable fire protection measures when installing polyurethane insulation products.

Economy and environment

The choice of rigid polyurethane foam as a building solution supports important economic and environmental considerations

Economic

- extremely light compared to alternative materials, reducing transportation costs and on-site handling and installation time
- easy to erect and install; saving time, reducing labour costs and making Health & Safety regulations easier to meet
- consistent factory quality; meaning fewer technical defects than site produced or assembled systems
- lower maintenance – offering reduced operating and repair costs for building owners

Environmental

- outstanding thermal insulation; reducing heating and cooling costs for the lifetime of a building
- long-lifetimes, maximizing natural resources used in its manufacture
- a significant contribution to reduced emission of greenhouse gases; in production, transportation and installation
- reclaimable and recyclable materials, with inherent energy value.

Insulation board and block

Versatile applications

Insulation board, which is sometimes referred to as “polyiso” or “boardstock” is used in many roofing, flooring and cavity wall applications.

Typical examples include:

Low slope roofing
An industry standard for use on metal or concrete roof decks. PU insulation boards are compatible with many systems e.g. built-up or membrane roof coverings.

Pitched roofs
Highly effective insulation beneath tiled or slated pitch roofs, creating an average 15% more usable roof space.

Cavity walls
Widely specified insulation for partial fill cavity walls, providing high insulation performance and eliminating thermal shorts through the studs.

Flooring insulation
Excellent insulant against heat loss from a ground floor, whether of solid concrete or suspended timber construction.

Insulation performance of polyurethane foam

Thickness (in)	1.0	2.0	3.5	6.0
Thermal conductivity, k (Btu/hr ft. F)	0.167	0.167	0.167	0.167
R-value (ft² F hr/Btu)	6.0	12.1	21.7	35.9
U-value (Btu/hr ft² F)	0.167	0.083	0.046	0.028

“In 2007 polyiso accounted for 73% of all insulation used in new (low slope) roof applications.”
Source IAL

Huntsman is a leading supplier of materials used to manufacture rigid foam Insulation Board and Block for use in residential and commercial buildings. ‘Boards’ are insulating products which are laminated on both surfaces with a variety of facing materials.

‘Block’ is polyurethane foam manufactured in blocks which is cut and shaped to required dimensions. Board and Block are highly versatile insulants suitable for use in many construction tasks, including low slope and pitched roofs, cavity walls, floors, internal linings, composite decks, pipes and tanks.

In 2008, about 4.8 billion board feet of polyiso was used by the North American construction industry (Source: PIMA). This figure is forecast to grow steadily due to new legislation governing energy consumption and greater awareness of the valuable role played by effective insulation. Most producers operate on a continuous production basis.

Working with insulation board and block
Insulation Board and Block is the most widely used rigid polyurethane foam product in the construction sector. Its popularity reflects a range of qualities which make it a simple and highly effective product to work with.

The primary benefit of rigid polyurethane foam is its outstanding insulation quality. This is also enhanced by a range of other practical benefits. Board and Block are extremely versatile in providing insulation for a variety of building applications. Board it fits neatly and unobtrusively into wall and roof cavities and can be used in conjunction with many facing materials to add specific properties and finishes.

In Block form, it is cut and shaped to fit large surfaces such as floors, or smaller areas where an insulant is required. Rigid polyurethane foam is light and simple to transport to and around building sites. It is a clean, non-hazardous material that requires no special handling, storage or specialist trade skills to work with. Equally, it is not temperature or moisture sensitive and can be fitted under most weather and climatic conditions.

Features and benefits of insulation board and block

Feature	Construction benefit
high thermal resistance	excellent insulant for domestic and commercial buildings
versatility	suitable for use in many varied applications and with different facing materials
good fire performance	proven by large scale testing, particularly compared to alternative insulants
ease of use/installation	light, clean, simple to install as board or cut in block applications
longevity	majority of installations will retain thermal qualities for at least 50 years

Spray polyurethane foam

Spray Polyurethane Foam (SPF) is an insulation product that is produced on-site and is typically applied by certified applicators. Two liquid components, polymeric MDI (A) and a polyol blend (B) are mixed at high or low pressure using a spray gun, and the reacting mix is sprayed onto the substrate. It expands and solidifies to form a polyurethane foam that adheres well to the area it is applied to, providing a seamless seal.

SPF insulation is ideal for roofs. It can also be sprayed into exterior wall cavities, or onto the exterior sheathing of commercial and residential buildings. SPF is compatible with many different wall types.

Types of Spray Foam

Closed cell

Sometimes known as 'two-pound' or medium density foam. It has a high R-value of around six per inch, and acts as an air and vapor barrier. It also provides structural enhancement.

Open cell

Sometimes known as 'half-pound' or low density foam. It has an R-value of 3.6 per inch, and may act as an air barrier. It also acts as a noise absorber.

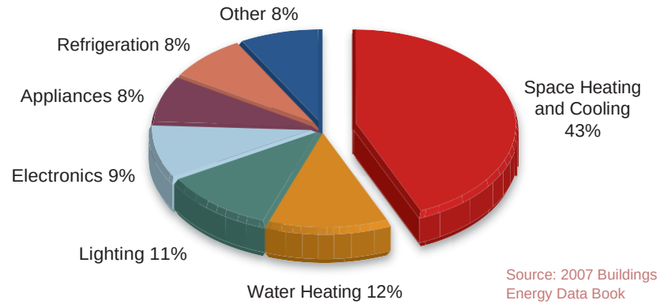
SPF for roofing

SPF applied to roofs is typically closed-cell foam and with a higher density of 2.7 – 3 pcf for greater structural benefit.

One-component foam

One-component polyurethane foam (OCF) is a self adhesive moisture curing gap filler with the main advantages being its portability and ease of application. OCF is supplied to the building and DIY industries in pressurized cans. OCF is ideal for weatherization, and is used to seal around openings e.g. windows, doors, skylights, base plates, and plumbing penetrations etc.

Homeowner Energy Cost Allocations



Source: 2007 Buildings Energy Data Book

"Air infiltration can account for 30% or more of a home's heating and cooling costs."

U.S. Department of Energy

Versatile applications

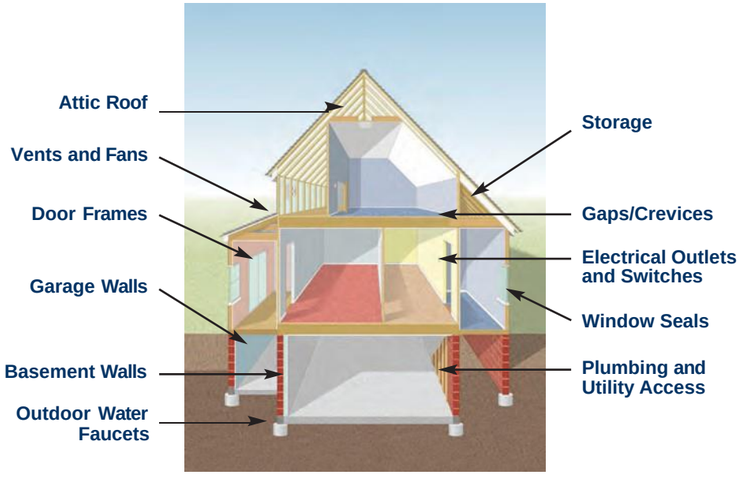
Spray Polyurethane Foam (SPF) is the ideal insulant for energy efficient commercial and residential buildings. SPF creates a watertight and airtight seal directly against a substrate to eliminate the effect of air infiltration. It can be applied to:

- **roofs**
- **in the interior wall cavity**
- **onto existing sheathing (reduces thermal shorts)**
- **attics**
- **walls**
- **storage**
- **rim joists**
- **floor slabs**

Features and benefits of Spray Foam insulation

Feature	Construction benefit
high R-value	prevents heat loss/insulates against cold
seamless air barrier	reduces unwanted air infiltration/exfiltration
water vapor retarder	controls mold damage
structural enhancement	prevents wind uplift in roofs
compatibility with different substrates	can be applied on many buildings
durability	longer service life and lower maintenance costs

SPF for weatherization in the home



Spray foam and one-component foams are ideal for weatherization

Insulated metal panels

Insulated Metal Panels (IMPs) are factory manufactured exterior panels that are typically used for a wide range of commercial and industrial buildings. Applications include cladding, partitioning, load bearing walls and roofing elements.

Panels are manufactured on a continuous lamination basis with metal facings (usually steel) encapsulating a foamed polyurethane core. The polyurethane foam thickness can reach eight inches, depending upon application and required insulation characteristics.

These versatile products are also known as 'sandwich' panels due to the physical interaction of the two materials. This composite offers a high degree of stability, rigidity and excellent load bearing capacity.

Working with insulated metal panels

The growth in use of Insulated Metal Panels has been driven by the construction industry's need for a lightweight panel with good thermal insulation qualities and simple on-site installation.

This requirement has been assisted by the technical development of rigid polyurethane foams offering very high insulation values, especially compared to site-assembled systems.

The ease of mounting Insulated Metal Panels to the building substructure is another major factor in the popularity of this product. Building times are significantly reduced compared to traditional methods, with consequent savings in labor costs.

Insulated Metal Panels offer architects and specifiers an exciting dimension in the planning, costing and design of new and refurbished buildings.

There is a wide and attractive choice of surface finishes available, both in terms of color and coatings. Hidden joints, combination options with other materials and foamed moldings for roofs and walls enable buildings of striking architectural value and appearance to be created.

Features and benefits of Insulated Metal Panels

Feature	Construction benefit
single manufactured unit	fast on-site erection = labor cost savings allows fast project completion minimizes on-site impact on product quality
high insulation value at low panel thickness	reduced energy costs for life of building dimensional space savings greater saleable/leasable building area
structural value combined air/water barrier	long span, high load construction performance material cost savings ease of construction
removable panels	design/refurbishment flexibility
low maintenance	low whole-life costs for building owner/tenant
surface treatments: texture and profiling	design/appearance flexibility

Versatile applications

The versatility of Insulated Metal Panels means they are increasingly used across many construction and renovation projects. The following list of popular applications includes specifications for Insulated Metal Panels as load bearing roof panels, wall cladding and partitioning:

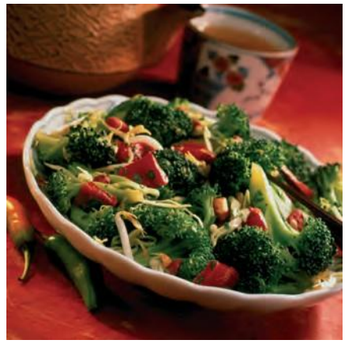
- administration centers
- airports
- climate-controlled rooms
- cold stores
- deep-freeze stores
- exhibition centerss
- factories
- hospitals
- hotels
- logistics centers
- power plants
- recycling facilities
- residential care homes
- retail stores
- schools
- sports centers
- warehouses
- waste incineration plants
- workshops

Pour-in-place insulation

‘Pour-in-Place’ insulation is a term used to capture a diverse range of rigid polyurethane foam applications. This category of products typically involves insulation of an item in a factory, by injecting polyurethane foam into a shell, cavity or space around the item.

Although fragmented, it is a major market for polyurethane foam. Typical applications for Pour-in-Place insulation products include refrigerators, freezers, water heaters, garage door panels, entry doors, refrigerated transport, picnic coolers, commercial display units etc.

Energy performance is a critical factor for specifiers, and this is usually measured in the final product by energy usage or heat leakage analysis. Achievement of these targets can be attained by the use of different blowing agent technologies, which produce specific performance characteristics in rigid polyurethane foam.



The cold chain: from harvesting the crops in the field to serving the meal at the table, polyurethane foam insulation plays a critical role in ensuring that the food we eat is stored, transported and prepared at the correct temperatures

Storage and transportation of hot water

One of the most important insulation tasks is in the production and storage of hot water, which requires less energy when stored in appropriately insulated boilers. This can be achieved by injecting rigid foam into the double metal cavity, or spraying directly onto the exterior of the boiler. Hot water used for municipal heating systems, or for industrial purposes can be protected against energy loss by using polyurethane foam pipe insulation.

Insulation for food storage and transportation

Insulation to assist chilling and refrigeration of foodstuffs throughout the supply chain is a primary function of rigid polyurethane foam in the Pour-in-Place insulation sector. Today, a majority of the freezers and refrigerators that are manufactured globally are insulated with polyurethane insulation. In food transport and delivery vehicles discontinuous panels allow the correct temperature controlled environment to be achieved. Similar products, but on a larger scale, are used in the construction of cold store factories, processing plants and warehouses.

At retail ‘point of sale’, chilled and refrigerated display units featuring polyurethane foam are present in virtually every food store in the developed world.

Mining

A niche application for rigid polyurethane and foam used to assist rock consolidation in mining works.

Structural insulated panels

Structural Insulated Panels (SIPS) consist of a rigid PU insulation foam core bonded to two OSB skins. The foam core acts as the insulation whilst the OSB skins are a structural component. SIPS are made as one panel to replace the wood frame construction, interior cavity insulation and vapour barrier. SIPS offers benefits in terms of production efficiency, air tightness and lower operating costs.

Features and benefits of Pour-in-Place insulation

Feature	Construction benefit
low thermal conductivity	energy savings
versatility	multi-application products in panel, injection or spray forms
Huntsman technology	custom foams with special characteristics
longevity	low maintenance with long term energy savings

Pipe insulation

Rigid polyurethane foam has been used for the insulation and protection of pipes for more than 30 years.

One of the main uses is in the insulation of oil and gas pipelines and district heating systems. Polyurethane foam insulation is also used in heating and plumbing services for power stations, chemical plants and refineries.

In heating systems, polyurethane insulation prevents heat loss, and in cold climates it helps maintain a warmer pipe temperature to avoid freezing or cracking. Polyurethane insulation provides high mechanical strength, flexibility and it flows well when installed – which is important when filling long pipe sections.

There are several methods and techniques by which foam can be applied. These can broadly be split between factory applied and in-situ application. In most cases, factory applied is preferred as it can be produced by continuous or discontinuous methods and is not dependent on favourable weather conditions.

Another distinction is between foam which is introduced into the cavity between the service pipe and the outer casing, and spray or pour applications which cover the exterior of the pipe with a layer of insulating foam.

Polyurethane foam is suitable for applications ranging from 0.5 inch diameter plumbing pipes, up to the largest district heating pipes with 80 inch diameters and 10 inches of insulation thickness.

Features and benefits of polyurethane pipe insulation

Feature	Construction benefit
low thermal conductivity	prevents heat loss/insulates against freezing
suited to wide temperature range	-500˚C to +570˚C
high flexibility	ease of handling/installation
factory manufactured or in-situ	production versatility to suit application
compatibility with pipe materials	works with steel, PE, PP, PVC or HDPE
exclusive Huntsman systems	combine flexibility with thermal resistance
longevity	low maintenance/long replacement cycle

Working with pipe insulation

Huntsman is an innovator in the development of flexible pipe technology, a product popular with contractors because of its ease of handling. Installation is simpler than with rigid products, as obstacles can be bypassed by bending the pipe.

After production, pipe is usually coiled and then laid in continuous lengths of several hundred yards, reducing the labour and cost of numerous joints and fixings. A further practical benefit is that the trench profile for flexible pipes is often narrower, resulting in lower plant and excavation costs.

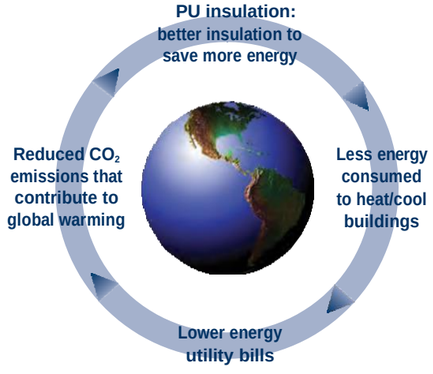
Achieving this combination of high flexibility and excellent thermal resistance has required materials engineered to overcome the problem of combining the inherently different chemical structures needed to produce each property. Experts at Huntsman have been at the forefront of this breakthrough.

Polyurethane for green buildings

According to the US EPAs Energy Star Program, “A green building must be an energy efficient one”. Polyurethane insulation products reduce the demand for the fossil fuel based energy used to heat and cool buildings, thereby reducing the harmful greenhouse gases associated with the production and transportation of these fuels. In addition, in reducing energy demand polyurethane insulation offers a solution to the real concerns of fossil fuel scarcity and energy security.

Use of polyurethane insulation products in residential and commercial buildings helps meet advanced energy codes e.g. Ashrae 90.1 and contributes towards green building certifications e.g. LEED®[1]. A study by McKinsey[2] concluded insulation is the single, most cost-effective measure to reduce greenhouse gases.

1. (Leadership in Energy and Environmental Design) Green Building Rating System is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. ‘LEED’ and related logo is a trademark owned by the U.S. Green Building Council and is used by permission.
2. “Reducing Greenhouse Gas Emissions: How Much And at What Cost?” McKinsey, December 2007.



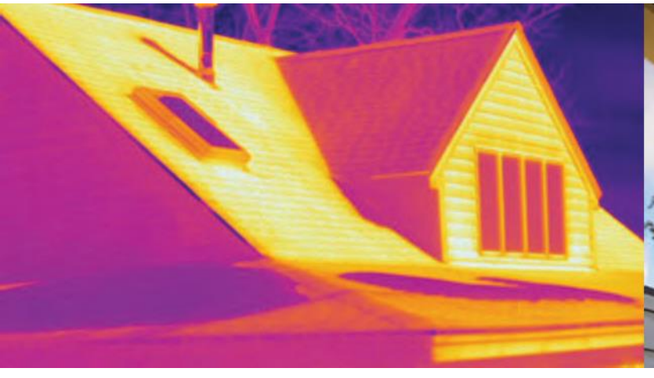
PU insulation contributes towards green certification

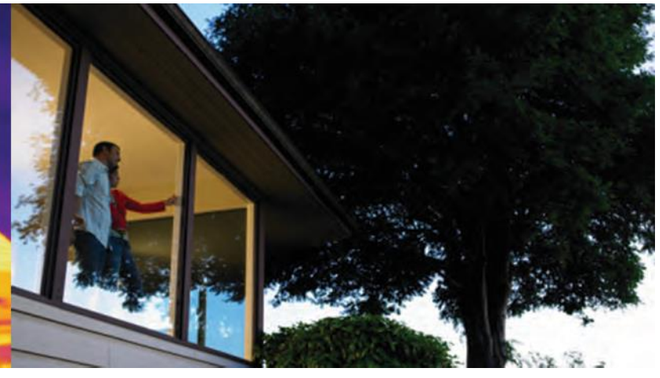
Programs e.g. LEED and Green Globes and the NAHB National Green Building Standard. Credits are typically obtained in the following sections:

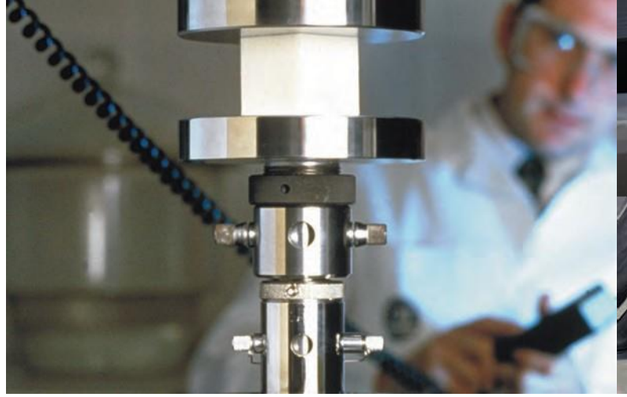
- **energy and atmosphere**
- **sustainable sites**
- **material and resource**
- **indoor environmental quality**
- **innovation in design**

The ratio of carbon dioxide emissions saved by foam plastics used as building insulation, compared to the carbon dioxide emissions used to produce foam plastics: 233:1

Source: McKinsey: “Innovations for Greenhouse Gas Emissions Reduction”, 2009







Commitment to the polyurethane insulation industry

Huntsman has been a long term supplier and partner to the international polyurethane insulation industry for more than 45 years. The company’s researchers and foam technologists work constantly to develop and refine foam systems to meet the needs of specifiers and engineers working with polyurethane based products.

Innovation and technical support

Typifying this commitment are three dedicated Huntsman centres of excellence for foam technology. The Huntsman Advanced Technology Center in The Woodlands, USA serves customers in the Americas. The Technical Center in Ternate, near Milan supplies Europe, Africa, Middle East and Indian sub-continent, while Singapore covers the needs of customers in the Asia/Pacific region.

Regional Technical Centers are supported by an international network of Technical Service Centers which offer comprehensive support to customers. Technical Service teams are available to help with selection of the most appropriate chemical systems, processes and product performance. Centers can also offer demonstrations and testing resources.

This structure of Regional and Technical centers provides customers in the construction industry direct access to the extensive resources of the Huntsman group of companies. This encourages close, long term working relationships to be established, with the shared goal of innovative new product development and worldwide service support.

Market extension and industry participation

Our market knowledge and expertise in sustainable construction, life cycle analysis, fire safety in buildings, makes Huntsman a recognized leader in driving market extension.

Huntsman takes an active role in polyurethane-related industry groups, reflecting our commitment to the industry.

SPRAY POLYURETHANE FOAM ALLIANCE SPFA

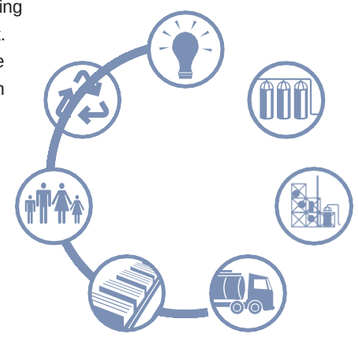
PIMA Polyisocyanurate Insulation Manufacturers Association

MCA Metal Construction Association

“Member: Center for the Polyurethanes Industry of the American Chemistry Council”.

Product Stewardship

The product stewardship process in place at Huntsman adds value to our products by minimizing the risk of harm to mankind and the environment. We assess our products at every stage in their life cycle, from the sourcing of raw materials, through manufacture and use, to eventual disposal. This involves us working very closely with our customers, suppliers and others in the supply chain to ensure that everybody understands the EHS issues related to our chemicals and to the polyurethanes products that are made.



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