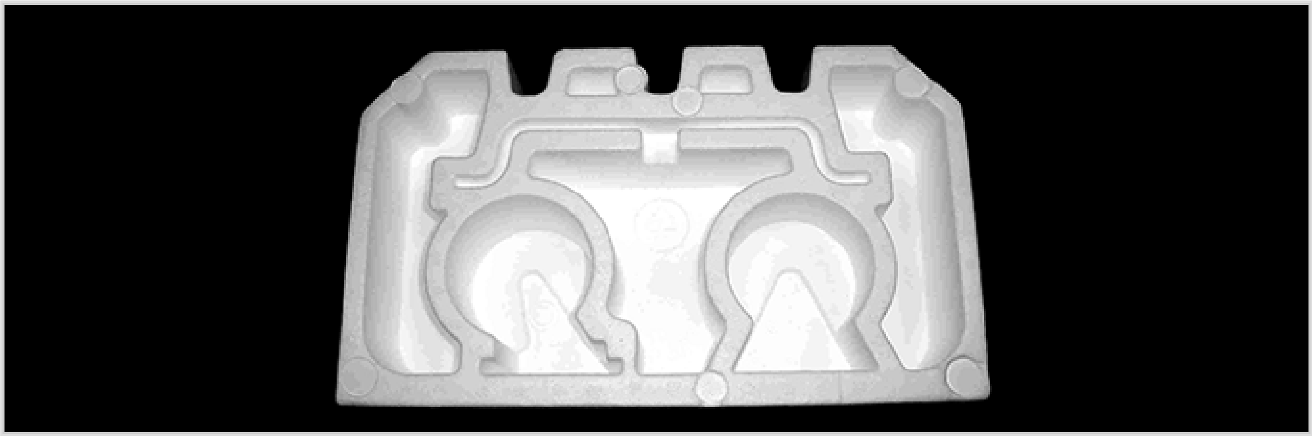
Rigid Polymer Foam (HD)

Description

Image



Caption

Rigid polystyrene foam is used for packaging, thermal insulation and sound absorption. © Granta Design

The material

Polymer foams are made by the controlled expansion and solidification of a liquid or melt through a blowing agent; physical, chemical or mechanical blowing agents are possible. The resulting cellular material has a lower density, stiffness and strength than the parent material, by an amount that depends on its relative density - the volume-fraction of solid in the foam. Rigid foams are made from polystyrene, phenolic, polyethylene, polypropylene or derivatives of polymethylmethacrylate. They are light and stiff, and have mechanical properties the make them attractive for energy management and packaging, and for lightweight structural use. Open-cell foams can be used as filters, closed cell foams as flotation. Self-skinning foams, called 'structural' or 'syntactic', have a dense surface skin made by foaming in a cold mold. Rigid polymer foams are widely used as cores of sandwich panels.

Composition (summary)

Hydrocarbon

General properties

Density	10.6	-	29.3	lb/ft^3
Price	* 6.95	-	7.65	USD/lb
Date first used	1931			

Mechanical properties

Young's modulus	0.029	-	0.0696	10^6 psi
Shear modulus	0.00798	-	0.0283	10^6 psi
Bulk modulus	0.029	-	0.0696	10^6 psi
Poisson's ratio	0.27	-	0.33	
Yield strength (elastic limit)	0.116	-	1.74	ksi
Tensile strength	0.174	-	1.8	ksi
Compressive strength	0.406	-	1.74	ksi
Elongation	2	-	10	% strain
Hardness - Vickers	0.28	-	1.2	HV
Fatigue strength at 10^7 cycles	* 0.122	-	1.39	ksi
Fracture toughness	0.0215	-	0.0824	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.005	-	0.15	

Thermal properties

Glass temperature	152	-	340	°F
Maximum service temperature	152	-	332	°F
Minimum service temperature	-172	-	-99.7	°F

Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0196	-	0.0364	BTU.ft/h.ft^2.F
Specific heat capacity	0.239	-	0.456	BTU/lb.°F
Thermal expansion coefficient	12.2	-	38.9	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e16	-	1e20	µohm.cm
Dielectric constant (relative permittivity)	1.21	-	1.45	
Dissipation factor (dielectric loss tangent)	8e-4	-	0.008	
Dielectric strength (dielectric breakdown)	153	-	279	V/mil

Optical properties

Transparency	Opaque

Processability

Castability	1	-	3
Moldability	3	-	4
Machinability	3	-	4
Weldability	1	-	2

Eco properties

Embodied energy, primary production	* 1.05e4	-	1.16e4	kcal/lb
CO2 footprint, primary production	* 3.68	-	4.07	lb/lb
Recycle	✗			

Supporting information

Design guidelines

Energy management and packaging requires the ability to absorb energy at a constant, controlled crushing stress; here polyurethane, polypropylene and polystyrene foams are used. Acoustic control requires the ability to absorb sound and damp vibration; polyurethane, polystyrene and polyethylene foams are all used. Thermal insulation requires long life; polyurethane foams were common but are now replaced by phenolics and polystyrenes. When fire-protection is needed phenolic foams are used. Foams are usually shaped by injecting or pouring a mix of polymer and foaming agent into a mold where the agent evolves gas, expanding the foam. The mix can be palletized, and the mold part-filled with solid pellets before foaming (see "Expanded foam molding" in this database). Expanding in a cold mold gives a solid surface skin, creating a sandwich-like structure with attractive mechanical properties.

Technical notes

The properties of foams depend, most directly, on the material of which they are made and on the relative density (the fraction of the foam that is solid). Most commercial foams have a relative density between 1% and 30%. To a lesser extent, the properties depend on the size and the shape of the cells. Low density, closed cell, foams have exceptional low thermal conductivity. Skinned rigid foams have good bending stiffness and strength of low weight.

Typical uses

Thermal insulation, Cores for sandwich structures, Panels, Partitions, Refrigeration, Energy Absorption, Packaging, Buoyancy, Floatation.

Links

Reference

ProcessUniverse

Producers