Paper and cardboard

Description

Image

Caption

1. Stack of copy paper. © Jonathan Joseph Bondhus at en.wikipedia - (CC BY-SA 3.0) 2. Corrugated cardboard. © Richard Wheeler (Zephyris) at en.wikipedia - (CC BY-SA 3.0)

The material

Papyrus, the forerunner of paper, was made from the flower stem of the reed, native to Egypt; it has been known and used for over 5000 years. Paper, by contrast, is a Chinese invention (105 AD). It is made from pulped cellulose fibers derived from wood, cotton or flax. There are many different types of paper and paper board: tissue paper - newsprint, kraft paper for packaging, office paper, fine glazed writing paper, cardboard - and a correspondingly wide range of properties. The data below span the range of newsprint and kraft paper.

Composition (summary)

Cellulose fibers, usually with filler and colorant

General properties

Density		30	-	53.7	lb/ft^3
Price	*	0.449	-	0.549	USD/lb
Date first used		105			

Mechanical properties

Young's modulus		0.435	-	1.29	10^6 psi
Shear modulus	*	0.145	-	0.29	10^6 psi
Bulk modulus	*	0.29	-	0.58	10^6 psi
Poisson's ratio		0.38	-	0.41	
Yield strength (elastic limit)		2.18	-	4.93	ksi
Tensile strength		3.34	-	7.4	ksi
Compressive strength		5.95	-	7.98	ksi
Elongation		0.75	-	2	% strain
Hardness - Vickers	*	4	-	9	HV
Fatigue strength at 10^7 cycles	*	1.89	-	3.48	ksi
Fracture toughness	*	5.46	-	9.1	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.05	-	0.2	

Thermal properties

Glass temperature		117	-	153	°F
Maximum service temperature		171	-	266	°F
Minimum service temperature		-459			°F
Thermal conductor or insulator?		Good insulator			
Thermal conductivity		0.0347	-	0.0982	BTU.ft/h.ft^2.F

Specific heat capacity	0.32	-	0.334	BTU/lb.°F
Thermal expansion coefficient	2.78	-	11.1	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e13	-	1e15	µohm.cm
Dielectric constant (relative permittivity)	2.5	-	6	
Dissipation factor (dielectric loss tangent)	0.015	-	0.04	
Dielectric strength (dielectric breakdown)	5.08	-	7.62	V/mil

Optical properties

Transparency	Opaque

Processability

Moldability	4	-	5	

Eco properties

Embodied energy, primary production	* 5.3e3	-	5.85e3	kcal/lb
CO2 footprint, primary production	* 1.11	-	1.23	lb/lb
Recycle	✓			

Supporting information

Technical notes

Paper is graded in "grammage", the weight, in grams, per unit area. typically 40 - 120 g/m^2. The "bulk" of paper is the reciprocal of its density. The typical sheet "caliper" or thickness of newsprint is 40 - 50 microns; that of bond paper 60 - 90 microns, paper board 120 - 300 microns. "Book bulk" is the number of sheets that, when stacked, have a thickness of 25 mm (1 inch). For newsprint this is 60 - 80, for office paper, it is 105 - 110.

Cellulose fibers (the main constituent of paper) swell in diameter by 15 - 20% from dry to water-saturated. Since most of the fibers in paper lie parallel, change of humidity can change the dimension of the sheet, affecting registration in printing, which therefore requires a controlled atmosphere. Typically moisture accounts of 6 - 9 % of the weight of paper. Friction, too, is important in printing and in packaging; the coefficient of friction of paper sliding on paper is 0.35 - 0.45.

Typical uses

Packaging, filtering, writing; printing; currency, electrical and thermal insulation; gaskets.

Further reading

General information about paper: http://www.paperonweb.com

Eco and thermal data from Hammond, G. and Jones, C. (2006) "Inventory of carbon and energy (ICE), Dept. of Mechanical Engineering, University of Bath, UK.

Links

Reference

ProcessUniverse