

General information

Designation

Quercus rubra (L)

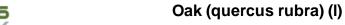
Typical uses

Lumber; sleepers; mine timbers; fenceposts; veneer; pulpwood; fuelwood; flooring; furniture; general millwork; boxes; pallets & crates; agricultural implements; caskets; woodenware; handles; railroad cars;

Composition overview

Compositional summary

Cellulose/Hemicellulose/Lignin/12%H2O					
Material family	Natural	Natural			
Base material	Wood (ha	Wood (hardwood)			
Renewable content	100		%		
Composition detail (polymers and natura	al materials)				
Wood	100			%	
Price					
Price	* 0.912	-	1.22	USD/lb	
Physical properties					
Density	0.0231	-	0.0282	lb/in^3	
Mechanical properties					
Young's modulus	* 1.8	-	2.2	10^6 psi	
Yield strength (elastic limit)	* 6.74	-	8.24	ksi	
Tensile strength	* 12	-	14.6	ksi	
Elongation	* 1.79	-	2.19	% strain	
Compressive strength	6.08	-	7.44	ksi	
Flexural modulus	1.64	-	2	10^6 psi	
Flexural strength (modulus of rupture)	12.9	-	15.7	ksi	
Shear modulus	* 0.133	-	0.162	10^6 psi	
Shear strength	1.6	-	1.96	ksi	
Bulk modulus	* 0.157	-	0.174	10^6 psi	
Poisson's ratio	* 0.35	-	0.4		
Shape factor	5.3				
Hardness - Vickers	* 6.78	-	8.28	HV	
Hardness - Brinell	* 6.58	-	8.04	ksi	
Hardness - Janka	* 1.52e3	-	1.86e3	lbf	
Fatigue strength at 10^7 cycles	* 3.86	-	4.71	ksi	





Mechanical loss coefficient (tan delta)	* 0.0067	-	0.0082	
Differential shrinkage (radial)	0.14	-	0.18	%
Differential shrinkage (tangential)	0.28	-	0.34	%
Radial shrinkage (green to oven-dry)	3.6	-	4.4	%
Tangential shrinkage (green to oven-dry)	7.7	-	9.5	%
Volumetric shrinkage (green to oven-dry)	12.3	-	15.1	%
Work to maximum strength	1.09	-	1.33	ft.lbf/in^3

Impact & fracture properties

Fracture toughness	* 5.28	-	6.46	ksi.in^0.5	
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Thermal properties

Glass temperature	171	-	216	°F
Maximum service temperature	248	-	284	°F
Minimum service temperature	* -99.4	-	-9.4	°F
Thermal conductivity	* 0.179	-	0.214	BTU.ft/hr.ft^2.°F
Specific heat capacity	0.396	-	0.408	BTU/lb.°F
Thermal expansion coefficient	* 1.11	-	6.11	μstrain/°F

Electrical properties

Electrical resistivity	1.27e14	-	1.55e14	µohm.cm
Dielectric constant (relative permittivity)	* 6.95	-	8.5	
Dissipation factor (dielectric loss tangent)	* 0.082	-	0.1	
Dielectric strength (dielectric breakdown)	* 10.2	-	15.2	V/mil

Magnetic properties

Magnetic type	Non-magnetic

Optical properties

Transparency	Opaque
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Durability

Water (fresh)	Limited use
Water (salt)	Limited use
Weak acids	Limited use
Strong acids	Unacceptable
Weak alkalis	Acceptable
Strong alkalis	Unacceptable
Organic solvents	Acceptable
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Good
Flammability	



Reference Shape

	Highl	y flamm	able	
Primary production energy, CO2 and water				
Embodied energy, primary production	4.996	3 -	5.5e3	BTU/lb
Sources 0.5 MJ/kg (Ximenes, 2006); 2 MJ/kg (Ximenes, 2006); 9.1 MJ/kg (Hammo MJ/kg (Ecoinvent v2.2); 26 MJ/kg (Ecoinvent v2.2)	nd and Jones, 200	08); 11.6 N	/J/kg (Hubba	ard and Bowe, 2010); 23.7
CO2 footprint, primary production	0.574	-	0.633	lb/lb
Sources 0.229 kg/kg (Ecoinvent v2.2); 0.412 kg/kg (Ecoinvent v2.2); 0.862 kg/kg	(Hammond and Jo	2008). O 000 kg/k	a (Hubbard and Rowe
Water usage	* 1.84e		2.03e4	in^3/lb
Processing energy, CO2 footprint & water				
Coarse machining energy (per unit wt removed)	* 472	-	522	BTU/lb
Coarse machining CO2 (per unit wt removed)	* 0.082	4 -	0.091	lb/lb
Fine machining energy (per unit wt removed)	* 2.886	3 -	3.19e3	BTU/lb
Fine machining CO2 (per unit wt removed)	* 0.503	-	0.556	lb/lb
Grinding energy (per unit wt removed)	* 5.566	3 -	6.15e3	BTU/lb
Grinding CO2 (per unit wt removed)	* 0.971	-	1.07	lb/lb
Recycling and end of life				
Recycle	×			
Recycle fraction in current supply	8.55	-	9.45	%
Downcycle	√			
Combust for energy recovery	√			
Heat of combustion (net)	* 8.496	3 -	9.16e3	BTU/lb
Combustion CO2	* 1.69	-	1.78	lb/lb
Landfill	√			
Biodegrade	√			