# Oak (quercus rubra) (t)

## General information

**Designation**

Quercus rubra (T)

**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 | | | |
| Base material | Wood (hardwood) | | | |
| Renewable content | 100 | | | % |

## Composition detail (polymers and natural materials)

| | | | | |
|---|---|---|---|---|
| Wood | 100 | | | % |

## Price

| | | | | |
|---|---|---|---|---|
| Price | * 0.912 | - | 1.22 | USD/lb |
| Price per unit volume | * 36.5 | - | 59.2 | USD/ft^3 |

## Physical properties

| | | | | |
|---|---|---|---|---|
| Density | 0.0231 | - | 0.0282 | lb/in^3 |

## Mechanical properties

| | | | | |
|---|---|---|---|---|
| Young's modulus | * 0.306 | - | 0.341 | 10^6 psi |
| Yield strength (elastic limit) | * 0.435 | - | 0.531 | ksi |
| Tensile strength | 0.725 | - | 0.885 | ksi |
| Elongation | * 0.7 | - | 0.86 | % strain |
| Compressive strength | 0.909 | - | 1.11 | ksi |
| Flexural modulus | 0.278 | - | 0.31 | 10^6 psi |
| Flexural strength (modulus of rupture) | * 0.725 | - | 0.885 | ksi |
| Shear modulus | * 0.0316 | - | 0.0434 | 10^6 psi |
| Shear strength | * 4.81 | - | 5.85 | ksi |
| Rolling shear strength | * 0.177 | - | 0.532 | ksi |
| Bulk modulus | * 0.157 | - | 0.174 | 10^6 psi |
| Poisson's ratio | * 0.02 | - | 0.04 | |
| Shape factor | 5.7 | | | |
| Hardness - Vickers | 5.16 | - | 6.31 | HV |
| Hardness - Brinell | * 22.7 | - | 27.7 | HB |

| | | | | | |
|---|---|---|---|---|---|
| Hardness - Janka | | 1.16e3 | - | 1.42e3 | lbf |
| Fatigue strength at 10^7 cycles | * | 0.218 | - | 0.265 | ksi |
| Mechanical loss coefficient (tan delta) | * | 0.016 | - | 0.021 | |
| 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 | * | 0.109 | - | 0.133 | ft.lbf/in^3 |

## Impact & fracture properties

| | | | | | |
|---|---|---|---|---|---|
| Fracture toughness | | 0.333 | - | 0.408 | ksi.in^0.5 |

## Thermal properties

| | | | | | |
|---|---|---|---|---|---|
| Glass temperature | | 171 | - | 216 | °F |
| Maximum service temperature | | 248 | - | 284 | °F |
| Minimum service temperature | * | -99.4 | - | -9.4 | °F |
| Thermal conductivity | * | 0.0641 | - | 0.078 | BTU.ft/hr.ft^2.°F |
| Specific heat capacity | | 0.396 | - | 0.408 | BTU/lb.°F |
| Thermal expansion coefficient | * | 17.5 | - | 23.4 | µstrain/°F |

## Electrical properties

| | | | | | |
|---|---|---|---|---|---|
| Electrical resistivity | * | 1.43e14 | - | 2.13e14 | µohm.in |
| Dielectric constant (relative permittivity) | * | 3.93 | - | 4.8 | |
| Dissipation factor (dielectric loss tangent) | * | 0.054 | - | 0.067 | |
| Dielectric strength (dielectric breakdown) | * | 25.4 | - | 50.8 | V/mil |

## Magnetic properties

| | |
|---|---|
| Magnetic type | Non-magnetic |

## Optical properties

| | |
|---|---|
| Transparency | Opaque |

## Critical materials risk

| | |
|---|---|
| Contains >5wt% critical elements? | No |

## 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 | Highly flammable |

## Primary production energy, CO2 and water

| | | | | |
|---|---|---|---|---|
| Embodied energy, primary production | 4.99e3 | - | 5.5e3 | BTU/lb |

Sources

0.5 MJ/kg (Ximenes, 2006); 2 MJ/kg (Ximenes, 2006); 9.1 MJ/kg (Hammond and Jones, 2008); 11.6 MJ/kg (Hubbard and Bowe, 2010); 23.7 MJ/kg (Ecoinvent v2.2); 26 MJ/kg (Ecoinvent v2.2)

| | | | | |
|---|---|---|---|---|
| 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 Jones, 2008); 0.909 kg/kg (Hubbard and Bowe, 2010)

| | | | | |
|---|---|---|---|---|
| Water usage | * 1.84e4 | - | 2.03e4 | in^3/lb |

## Processing energy, CO2 footprint & water

| | | | | |
|---|---|---|---|---|
| Coarse machining energy (per unit wt removed) | * 244 | - | 270 | BTU/lb |
| Coarse machining CO2 (per unit wt removed) | * 0.0426 | - | 0.0471 | lb/lb |
| Fine machining energy (per unit wt removed) | * 605 | - | 668 | BTU/lb |
| Fine machining CO2 (per unit wt removed) | * 0.106 | - | 0.117 | lb/lb |
| Grinding energy (per unit wt removed) | * 1.01e3 | - | 1.11e3 | BTU/lb |
| Grinding CO2 (per unit wt removed) | * 0.175 | - | 0.194 | 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) | * 8.49e3 | - | 9.16e3 | BTU/lb |
| Combustion CO2 | * 1.69 | - | 1.78 | lb/lb |
| Landfill | ✓ | | | |
| Biodegrade | ✓ | | | |

## Notes

**Warning**

All woods have properties which show variation; they depend principally on growth conditions and moisture

## Links

| |
|---|
| ProcessUniverse |
| Reference |
| Shape |