Brass

Description

Image

Caption

1. French horn. © Copper Development Association 2. Pump parts. © Copper Development Association

The material

Brasses are alloys of copper (Cu) with 5 - 40% zinc (Zn). They combine excellent formability and machinability with good corrosion resistance. As the zinc content increases the melting point, density, modulus and electrical and thermal conductivities decrease; the expansion coefficient, the strength and the hardness increase.

Composition (summary)

Alpha,"70-30" or Cartridge brass: Cu + 30% Zn
Alpha-Beta, "60-40" or Naval brass: Cu + 40% Zn, often with a little lead

General properties

Density	493	-	534	lb/ft^3
Price	* 2.51	-	2.77	USD/lb
Date first used	-1200			

Mechanical properties

Young's modulus	13.1	-	16	10^6 psi
Shear modulus	5.08	-	6.09	10^6 psi
Bulk modulus	14.5	-	16.8	10^6 psi
Poisson's ratio	0.34	-	0.35	
Yield strength (elastic limit)	13.8	-	72.5	ksi
Tensile strength	45	-	79.8	ksi
Compressive strength	13.8	-	72.5	ksi
Elongation	5	-	60	% strain
Hardness - Vickers	65	-	220	HV
Fatigue strength at 10^7 cycles	21.8	-	36.3	ksi
Fracture toughness	27.3	-	54.6	ksi.in^0.5
Mechanical loss coefficient (tan delta)	1e-4	-	5e-4	

Thermal properties

Melting point	1.62e3	-	1.77e3	°F
Maximum service temperature	410			°F
Minimum service temperature	-459			°F
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	57.8	-	75.1	BTU.ft/h.ft^2.F
Specific heat capacity	0.0889	-	0.0915	BTU/lb.°F
Thermal expansion coefficient				

	9.44	-	11.5	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	8	-	10	µohm.cm

Optical properties

Transparency	Opaque

Processability

Castability	4	-	5
Formability	4	-	5
Machinability	4	-	5
Weldability	4	-	5
Solder/brazability	5		

Durability: water and aqueous solutions

Water (fresh)	Excellent
Water (salt)	Excellent
Soils, acidic (peat)	Acceptable
Soils, alkaline (clay)	Excellent
Wine	Acceptable

Durability: acids

Acetic acid (10%)	Limited use
Acetic acid (glacial)	Unacceptable
Citric acid (10%)	Limited use
Hydrochloric acid (10%)	Unacceptable
Hydrochloric acid (36%)	Unacceptable
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Unacceptable
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Limited use
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Limited use
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

Sodium hydroxide (10%)	Excellent
Sodium hydroxide (60%)	Acceptable

Durability: fuels, oils and solvents

Amyl acetate	Limited use
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Acceptable
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Limited use
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent

White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Limited use
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Acceptable
Formaldehyde (40%)	Acceptable
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Excellent
Fluorine (gas)	Acceptable
O2 (oxygen gas)	Limited use
Sulfur dioxide (gas)	Limited use

Durability: built environments

Industrial atmosphere	Acceptable
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Excellent
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Acceptable
Tolerance up to 450 C (842 F)	Unacceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Geo-economic data for principal component

Annual world production	1.56e7			ton/yr
Reserves	5.31e8			l. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 5.66e3	-	6.25e3	kcal/lb
CO2 footprint, primary production	* 3.38	-	3.74	lb/lb
Water usage	* 36.7	-	40.5	gal(US)/lb
Eco-indicator 95	1.4e3			millipoints/kg
Eco-indicator 99	1.77e3			millipoints/kg

Material processing: energy

Casting energy	* 896	-	990	kcal/lb
Extrusion, foil rolling energy	* 316	-	350	kcal/lb
Rough rolling, forging energy	* 173	-	192	kcal/lb
Wire drawing energy	* 1.11e3	-	1.21e3	kcal/lb
Metal powder forming energy	* 2.29e3	-	2.55e3	kcal/lb
Vaporization energy	* 9.93e5	-	1.09e6	kcal/lb
Coarse machining energy (per unit wt removed)	* 72.8	-	80.5	kcal/lb
Fine machining energy (per unit wt removed)	* 265	-	294	kcal/lb

Grinding energy (per unit wt removed)	* 479	-	530	kcal/lb
Non-conventional machining energy (per unit wt removed)	9.93e3	-	1.09e4	kcal/lb

Material processing: CO2 footprint

Casting CO2	* 0.62	-	0.685	lb/lb
Extrusion, foil rolling CO2	* 0.219	-	0.242	lb/lb
Rough rolling, forging CO2	* 0.12	-	0.133	lb/lb
Wire drawing CO2	* 0.762	-	0.842	lb/lb
Metal powder forming CO2	* 1.69	-	1.88	lb/lb
Vaporization CO2	* 688	-	760	lb/lb
Coarse machining CO2 (per unit wt removed)	* 0.0504	-	0.0557	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.184	-	0.203	lb/lb
Grinding CO2 (per unit wt removed)	* 0.332	-	0.367	lb/lb
Non-conventional machining CO2 (per unit wt removed)	6.88	-	7.6	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 1.31e3	-	1.45e3	kcal/lb
CO2 footprint, recycling	* 0.954	-	1.05	lb/lb
Recycle fraction in current supply	45	-	60	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Brass is non-toxic and readily recycled

Supporting information

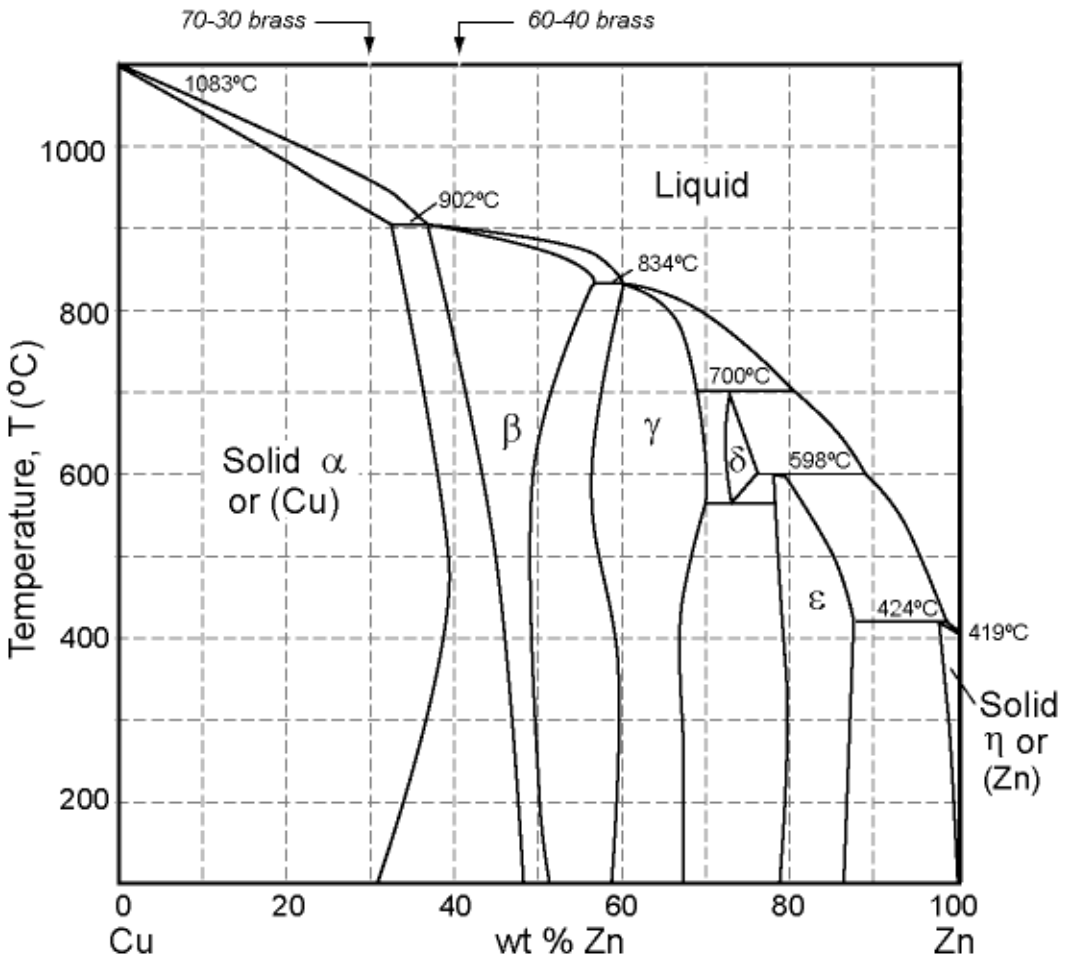
Design guidelines

Brasses are readily worked by casting, drawing, spinning and machining. They have a pleasing color ranging from the red of copper through browner bronze-like hues and gold (jewelry brass closely resembles the color of 14 carat gold).

Technical notes

There is now a UNS designation system for copper and its alloys: the letter C (for 'copper') followed by a 5-digit number. Only the first digit means anything: C1**** designates almost pure copper, the C2, C3 and C4 series are brasses with increasing zinc content, the C5s are bronzes based on copper and tin, the C6s are other bronzes containing aluminum instead of tin, and the C7s are copper-nickel alloys. More information on designations and equivalent grades can be found on the Granta Design website at www.grantadesign.com/designations

Phase diagram



Phase diagram description

Brasses are alloys of copper (Cu) with 5 - 40% zinc (Zn), for which this is the phase diagram. The two most widely used compositions are 70-30 brass and 60-40 brass. Their compositions are shown.

Typical uses

70-30 Brasses: deep drawn parts such as cartridge and shell casings; musical instruments and other objects made by sheet-metal working; decorative components for architecture; marine components; condenser and cooling units; jewelry.60-40 Brasses: tubing for condensers; heat exchangers; valve and pump parts; taps and water pipes; fasteners and springs.

Tradenames

Red brass (15% Zn); Jewelry brass (12.5% Zn); Yellow brass (35% Zn); Muntz metal (40% Zn).

Links

Reference

ProcessUniverse

Producers