Description

Image



Caption

1. Zinc bucket. © Jon Pallbo, Pallbo at en.wikipedia - Public domain 2. Close-up of the Zinc bucket. © Jon Pallbo, Pallbo at en.wikipedia - Public domain 3. Guard rail along the road. © Pudding4brains at en.wikipedia - Public domain

The material

Zinc is a bluish-white metal with a low melting point (420 C). The slang in French for a bar or pub is "le zinc"; bar counters in France used to be clad in zinc - many still are - to protect them from the ravages of wine and beer. Bar surfaces have complex shapes - a flat top, curved profiles, rounded or profiled edges. These two sentences say much about zinc: it is ductile; it is hygienic; it survives exposure to acids (wine), to alkalis (cleaning fluids), and to misuse (upset customers). These remain among the reasons it is still used today. Another is the "castability" of zinc alloys - their low melting point and fluidity gives them a leading place in die-casting.

Composition (summary)

99.5%

General properties

Density	445	-	446	lb/ft^3
Price	* 0.907	-	0.998	USD/lb
Date first used	1746			

Mechanical properties

Young's modulus	13.1	-	15.5	10^6 psi
Shear modulus	* 4.93	-	6.38	10^6 psi
Bulk modulus	10.2	-	13.1	10^6 psi
Poisson's ratio	* 0.25	-	0.33	
Yield strength (elastic limit)	10.9	-	24.1	ksi
Tensile strength	13.1	-	29	ksi
Compressive strength	10.9	-	24.1	ksi
Elongation	10	-	70	% strain
Hardness - Vickers	20	-	50	HV

Fatigue strength at 10^7 cycles	* 7.25	-	13.1	ksi
Fracture toughness	* 27.3	-	63.7	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.002	-	0.008	

Thermal properties

Melting point	752	-	788	°F
Maximum service temperature	* 176	-	230	°F
Minimum service temperature	-67.3	-	-45.7	°F
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	57.8	-	72.2	BTU.ft/h.ft^2.F
Specific heat capacity	0.092	-	0.0967	BTU/lb.°F
Thermal expansion coefficient	12.8	-	15.6	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	5.4	-	6.3	µohm.cm

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

Castability	5			
Formability	2	-	3	
Machinability	5			
Weldability	3	-	4	
Solder/brazability	4	-	5	

Durability: water and aqueous solutions

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

Durability: acids

Acetic acid (10%)	Limited use
Acetic acid (glacial)	Limited use
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%)	Acceptable
Sodium hydroxide (60%)	Acceptable

Durability: fuels, oils and solvents

Amyl acetate	Excellent
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	Excellent
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

Chlorine gas (dry)	Acceptable
Fluorine (gas)	Acceptable

O2 (oxygen gas)	Unacceptable
Sulfur dioxide (gas)	Limited use

Durability: built environments

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

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Unacceptable
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, principal component	1.09e7	ton/yr
Reserves, principal component	1.97e8	l. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 4.76e3	-	5.25e3	kcal/lb
CO2 footprint, primary production	* 3.13	-	3.45	lb/lb
Water usage	* 39.2	-	43.3	gal(US)/lb
Eco-indicator 95	3.2e3			millipoints/kg
Eco-indicator 99	783			millipoints/kg

Material processing: energy

Casting energy	* 696	-	769	kcal/lb
Extrusion, foil rolling energy	* 258	-	286	kcal/lb
Rough rolling, forging energy	* 144	-	160	kcal/lb
Wire drawing energy	* 884	-	977	kcal/lb
Metal powder forming energy	* 1.02e3	-	1.12e3	kcal/lb
Vaporization energy	* 4.64e5	-	5.12e5	kcal/lb
Coarse machining energy (per unit wt removed)	* 68.5	-	75.7	kcal/lb
Fine machining energy (per unit wt removed)	* 222	-	246	kcal/lb
Grinding energy (per unit wt removed)	* 392	-	434	kcal/lb
Non-conventional machining energy (per unit wt removed)				

	4.64e3	-	5.12e3	kcal/lb

Material processing: CO2 footprint

Casting CO2	* 0.482	-	0.532	lb/lb
Extrusion, foil rolling CO2	* 0.179	-	0.198	lb/lb
Rough rolling, forging CO2	* 0.1	-	0.111	lb/lb
Wire drawing CO2	* 0.612	-	0.676	lb/lb
Metal powder forming CO2	* 0.75	-	0.827	lb/lb
Vaporization CO2	* 321	-	355	lb/lb
Coarse machining CO2 (per unit wt removed)	* 0.0474	-	0.0524	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.154	-	0.17	lb/lb
Grinding CO2 (per unit wt removed)	* 0.272	-	0.3	lb/lb
Non-conventional machining CO2 (per unit wt removed	3.21	-	3.55	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 1.15e3	-	1.28e3	kcal/lb
CO2 footprint, recycling	* 0.836	-	0.924	lb/lb
Recycle fraction in current supply	20	-	25	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Zinc vapor is toxic - if you inhale it you get the "spelter-shakes" - but adequate protection is now universal. In all other ways zinc is a star: it is non-toxic, has low energy content, and - in bulk - can be recycled (not, of course, as plating).

Supporting information

Design guidelines

Zinc is used as cladding and in galvanizing steel to improve corrosion resistance. Wrought zinc is available as strip, sheet, foil, plate, rod, wire and blanks for forging or extrusion. It is relatively soft (a strength of 60 - 120 MPa) but, because of its hexagonal structure, bends in rolled zinc sheet should be at right angles to the grain or rolling direction and should have a radius no less than the sheet thickness. Wrought zinc alloys are easily soldered and spot-welded. It can be polished, textured, plated or painted. When exposed to air, zinc develops a surface film of carbonate that is very protective; it is frequently left uncoated.

Technical notes

Wrought zinc is made by hot-rolling cast sheets, by extrusion or by drawing. Zinc foil is made by electroplating zinc on an aluminum drum and then stripping it off.

Typical uses

Galvanizing of steel and other protective plating, cladding, flashing and guttering of buildings, flashlight reflectors, radio shielding, gaskets, photo-engraving plates, kitchen counter-tops, electrodes for zinc-carbon batteries.

Links

Reference

ProcessUniverse

Producers