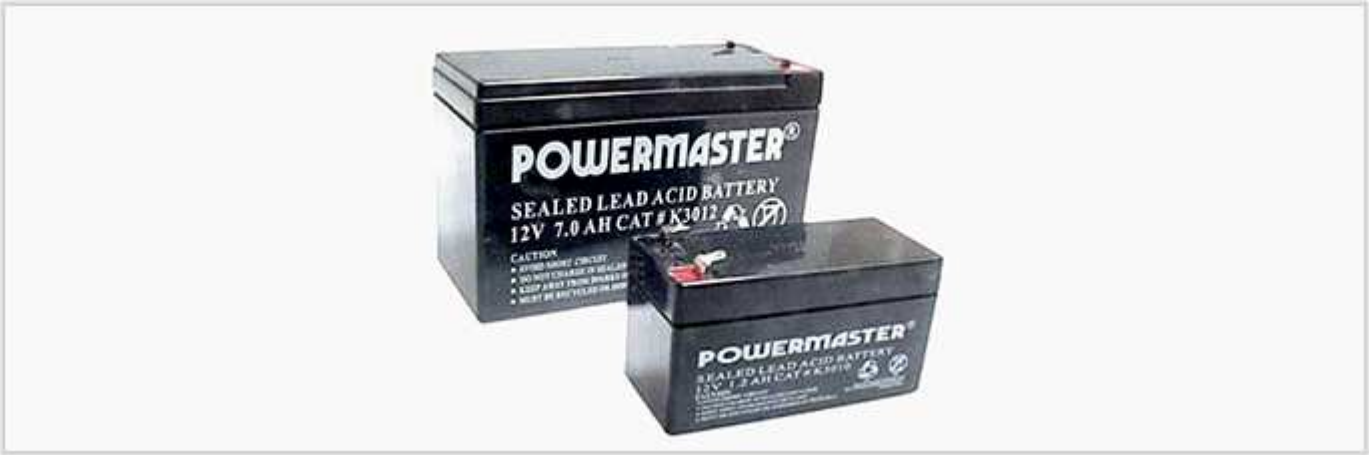
Description

Image



Caption

The single largest use of metallic lead is as electrodes for lead-acid batteries, accounting for 70% of all production.

The material

When the Romans conquered Britain in 43AD they discovered rich deposits of lead ore and started a mining and refining industry that was to continue for 1000 years (the symbol for lead - Pb - derives from its Latin name: Plumbum). They used it for pipes, cisterns, and for roofs - this last a use that continues to the present day. For many years tea was wrapped in lead foil to protect it on the sea voyage from India. The use of lead in many applications is diminishing because of the long-term toxic nature of lead salts, but its qualities as an acoustic insulator and its outstanding resistance to atmospheric corrosion still make it an attractive material for architecture.

Composition (summary)

>99.5 Pb

General properties

Density		1.13e4	-	1.14e4	kg/m^3
Price	*	1.82	-	1.97	USD/kg
Date first used		-6500			

Mechanical properties

Young's modulus		13	-	15	GPa
Shear modulus	*	4	-	6	GPa
Bulk modulus		30	-	45	GPa
Poisson's ratio	*	0.435	-	0.445	
Yield strength (elastic limit)		4	-	12	MPa
Tensile strength		12	-	20	MPa
Compressive strength		4	-	12	MPa
Elongation		30	-	60	% strain
Hardness - Vickers		3	-	6.5	HV
Fatigue strength at 10^7 cycles		2	-	9	MPa

Fracture toughness	* 5	-	15	MPa.m^0.5
Mechanical loss coefficient (tan delta)	* 0.065	-	0.14	

Thermal properties

Melting point	322	-	328	℃
Maximum service temperature	* 60	-	90	℃
Minimum service temperature	-273	-	-272	℃
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	33	-	36	W/m.℃
Specific heat capacity	122	-	135	J/kg.℃
Thermal expansion coefficient	28	-	31	µstrain/℃

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	20	-	22	µohm.cm

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

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

Durability: water and aqueous solutions

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

Durability: acids

Acetic acid (10%)	Excellent
Acetic acid (glacial)	Excellent
Citric acid (10%)	Excellent
Hydrochloric acid (10%)	Excellent
Hydrochloric acid (36%)	Limited use

Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Acceptable
Nitric acid (70%)	Acceptable
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Excellent

Durability: alkalis

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

Durability: fuels, oils and solvents

Amyl acetate	Acceptable
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Acceptable
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)	Unacceptable
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

Chlorine gas (dry)	Excellent
Fluorine (gas)	Excellent
O2 (oxygen gas)	Acceptable

Sulfur dioxide (gas)	Excellent

Durability: built environments

Industrial atmosphere	Excellent
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)	Acceptable
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	3.9e6	tonne/yr
Reserves, principal component	7.9e7	tonne

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 25.7	-	28.4	MJ/kg
CO2 footprint, primary production	* 1.83	-	2.02	kg/kg
Water usage	* 328	-	362	l/kg
Eco-indicator 95	640			millipoints/kg
Eco-indicator 99	284			millipoints/kg

Material processing: energy

Casting energy	* 5.14	-	5.68	MJ/kg
Extrusion, foil rolling energy	* 0.344	-	0.38	MJ/kg
Rough rolling, forging energy	* 0.315	-	0.348	MJ/kg
Wire drawing energy	* 0.506	-	0.56	MJ/kg
Metal powder forming energy	* 5.16	-	5.69	MJ/kg
Vaporization energy	* 917	-	1.01e3	MJ/kg
Coarse machining energy (per unit wt removed)	* 0.479	-	0.53	MJ/kg
Fine machining energy (per unit wt removed)	* 0.519	-	0.574	MJ/kg
Grinding energy (per unit wt removed)	* 0.564	-	0.623	MJ/kg
Non-conventional machining energy (per unit wt removed)	9.17	-	10.1	MJ/kg

Material processing: CO2 footprint

Casting CO2	* 0.386	-	0.426	kg/kg
Extrusion, foil rolling CO2	* 0.0258	-	0.0285	kg/kg
Rough rolling, forging CO2	* 0.0236	-	0.0261	kg/kg
Wire drawing CO2	* 0.038	-	0.042	kg/kg
Metal powder forming CO2	* 0.413	-	0.455	kg/kg
Vaporization CO2	* 68.8	-	76	kg/kg
Coarse machining CO2 (per unit wt removed)	* 0.036	-	0.0397	kg/kg
Fine machining CO2 (per unit wt removed)	* 0.0389	-	0.043	kg/kg
Grinding CO2 (per unit wt removed)	* 0.0423	-	0.0467	kg/kg
Non-conventional machining CO2 (per unit wt removed	0.688	-	0.76	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 7.08	-	7.83	MJ/kg
CO2 footprint, recycling	* 0.556	-	0.615	kg/kg
Recycle fraction in current supply	70	-	75	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✗			
Biodegrade	✗			
Toxicity rating	Toxic			
A renewable resource?	✗			

Environmental notes

Lead is one of the "heavy metals" that include cadmium, thallium and mercury. They have a bad reputation: when ingested they accumulate in the body, causing slow poisoning. It is for this reason that lead has been eliminated as an additive to petrol and as a pigment in paint, and that alternatives are sought for lead-tin solders. Lead in decorative and architectural applications offers no threat and is easily recycled.

Supporting information

Design guidelines

Lead is easy to shape because it melts at a low temperature (328 C) and is soft and ductile. It is exceptionally corrosion resistant, weathers to an attractive patina, and has good sound-insulating properties. It is readily cast to complex shapes in cheap molds, can be cut, soldered or welded with ease, and requires no special finishing or protective coating.

Technical notes

Lead, with an atomic weight of 207, is one of the heaviest of elements. For this reason it is used for flywheels, counter weights, projectiles (bullets) and X-ray shielding.

Typical uses

Roofs, wall cladding, pipe work, window seals, and flooring in buildings, sculpture and table wear as pewter, solder for electrical circuits and for mechanical joining, bearings, printing type, ammunition, pigments, X-ray shielding, corrosion resistant material in the chemical industry, electrodes for lead acid batteries, protective cable coverings.

Links

Reference

ProcessUniverse

Producers