Description

Image

Caption

1. Organ pipes are made of tin or of a tin - lead alloy. 2. Close-up of the material. © Håkan Svensson (Xauxa) at en.wikipedia - (CC BY-SA 3.0)

The material

Tin (symbol Sn) has been know to man since at least 3500 BC. The discovery that copper alloyed with tin to give bronze, greatly improving the mechanical properties, launched the Bronze age. In 1800 Napoleon offered prize of 12,000 francs for a method for preserving food for his armies. The tin can (steel coated with tin), which revolutionise the storage and preservation of foodstuffs and liquids, was invented in 1810, ironically by an Englishman; the first commercial canning factory opened just 3 years later.

Composition (summary)

Tin, Sn.

General properties

Density	453	-	454	lb/ft^3
Price	* 10.2	-	11.3	USD/lb
Date first used	-3500			

Mechanical properties

Young's modulus	5.95	-	6.53	10^6 psi
Shear modulus	2.03	-	2.61	10^6 psi
Bulk modulus	5.51	-	6.67	10^6 psi
Poisson's ratio	0.325	-	0.335	
Yield strength (elastic limit)	1.02	-	2.18	ksi
Tensile strength	1.6	-	2.61	ksi
Compressive strength	1.02	-	2.18	ksi
Elongation	55	-	75	% strain
Hardness - Vickers	3	-	5	HV
Fatigue strength at 10^7 cycles	* 0.58	-	1.31	ksi
Fracture toughness	* 13.7	-	27.3	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.015	-	0.045	

Thermal properties

Melting point	446	-	450	°F
Maximum service temperature	* 194	-	212	°F
Minimum service temperature	32	-	55.8	°F
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	34.7	-	35.5	BTU.ft/h.ft^2.F

Specific heat capacity	0.0516	-	0.0545	BTU/lb.°F
Thermal expansion coefficient	12.5	-	13.1	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	10	-	12	µohm.cm

Optical properties

Transparency	Opaque

Processability

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

Durability: water and aqueous solutions

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

Durability: acids

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

Durability: alkalis

Sodium hydroxide (10%)	Limited use
Sodium hydroxide (60%)	Limited use

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Limited use
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	Acceptable
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable
O2 (oxygen gas)	Limited use
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	Unacceptable
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	3.02e5	ton/yr
Reserves	5.51e6	l. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 2.34e4	-	2.58e4	kcal/lb
CO2 footprint, primary production	* 12.5	-	13.8	lb/lb
Water usage	* 1.25e3	-	1.38e3	gal(US)/lb

Material processing: energy

Casting energy	* 587	-	649	kcal/lb
Extrusion, foil rolling energy	* 50.2	-	55.5	kcal/lb
Rough rolling, forging energy	* 40.5	-	44.7	kcal/lb
Wire drawing energy	* 103	-	114	kcal/lb
Metal powder forming energy	* 447	-	492	kcal/lb
Vaporization energy	* 2.59e5	-	2.86e5	kcal/lb
Coarse machining energy (per unit wt removed)	* 52.9	-	58.5	kcal/lb
Fine machining energy (per unit wt removed)	* 65.9	-	72.8	kcal/lb
Grinding energy (per unit wt removed)	* 80.4	-	88.8	kcal/lb
Non-conventional machining energy (per unit wt removed)				

		2.59e3	-	2.86e3	kcal/lb

Material processing: CO2 footprint

Casting CO2	*	0.407	-	0.45	lb/lb
Extrusion, foil rolling CO2	*	0.0347	-	0.0384	lb/lb
Rough rolling, forging CO2	*	0.028	-	0.031	lb/lb
Wire drawing CO2	*	0.0714	-	0.0789	lb/lb
Metal powder forming CO2	*	0.33	-	0.364	lb/lb
Vaporization CO2	*	179	-	198	lb/lb
Coarse machining CO2 (per unit wt removed)	*	0.0366	-	0.0405	lb/lb
Fine machining CO2 (per unit wt removed)	*	0.0456	-	0.0504	lb/lb
Grinding CO2 (per unit wt removed)	*	0.0556	-	0.0615	lb/lb
Non-conventional machining CO2 (per unit wt removed)		1.79	-	1.98	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✓				
Embodied energy, recycling	*	3.87e3	-	4.27e3	kcal/lb
CO2 footprint, recycling	*	2.8	-	3.1	lb/lb
Recycle fraction in current supply		5.5	-	6.5	%
Downcycle	✓				
Combust for energy recovery	✗				
Landfill	✓				
Biodegrade	✗				
Toxicity rating	Non-toxic				
A renewable resource?	✗				

Environmental notes

Tin(II) salts can be poisonous by ingestion and other routes, and there is evidence that tin can have experimental carcinogenic and human mutagenic effects. Some organo-tin compounds are very toxic.

Supporting information

Technical notes

Tin is extracted by the reduction of cassiterite, SnO2, with carbon. At normal temperatures tin is metallic ("white" tin), but below 13.2 C it transforms (slowly) to non-metallic gray tin -- a problem known as "tin pest" when tin is used at low temperatures.

Typical uses

Tin is used in pure form in storage tanks for pharmaceutical chemical solutions, as electrodes of capacitors, and fuse wire and as organ pipes (though usually alloyed with some lead). Its most important applications, however, are as a coating on steel sheet ("tin plate") and as an alloying element in bronze, pewter and solder. Its salts are used as polymer additives, for antifouling paints, and to produce a transparent, conducting coating on glass.

Further reading

Eco data from Hammond, G. and Jones, C. (2006) "Inventory of carbon and energy (ICE), Dept. of Mechanical Engineering, University of Bath, UK

Links

Reference

ProcessUniverse

Producers