Bismuth, commercial purity

General information

Designation

Bismuth Metal (as sold on world commodity markets)

Typical uses

Alloying element; Pharmaceuticals; Electronics; Catalysts; Cosmetics; Pigments; Medicines; Thermocouples; Carrier for Uranium fuel in nuclear reactors; Fire sensing equipment;

Composition overview

Compositional summary

Bi100

Material family	Metal (other)
Base material	Bi (Bismuth)

Composition detail (metals, ceramics and glasses)

Bi (bismuth)	100			%

Price

Price	*	8.28	-	9.13	USD/lb

Physical properties

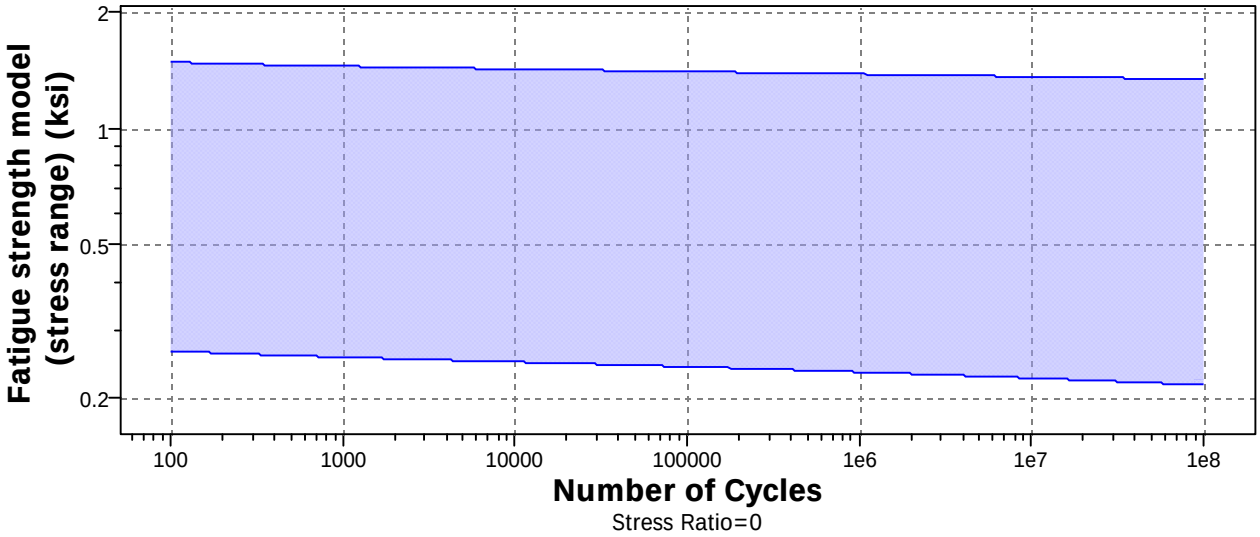
Density	0.352	-	0.354	lb/in^3

Mechanical properties

Young's modulus		4.79	-	5.08	10^6 psi
Yield strength (elastic limit)	*	0.29	-	2.03	ksi
Tensile strength		0.58	-	2.9	ksi
Elongation	*	20	-	30	% strain
Compressive strength	*	0.29	-	2.03	ksi
Flexural modulus	*	4.79	-	5.08	10^6 psi
Flexural strength (modulus of rupture)	*	0.29	-	2.03	ksi
Shear modulus		1.74	-	1.96	10^6 psi
Bulk modulus		4.5	-	5.22	10^6 psi
Poisson's ratio		0.325	-	0.335	
Shape factor		30			
Hardness - Vickers	*	5	-	10	HV
Fatigue strength at 10^7 cycles	*	1.16	-	1.45	ksi
Fatigue strength model (stress range)	*	0.226	-	1.36	ksi

Parameters: Stress Ratio = 0, Number of Cycles = 1e7cycles

Bismuth, commercial purity



Mechanical loss coefficient (tan delta)	* 0.02	-	0.2	

Impact & fracture properties

Fracture toughness	* 4.55	-	18.2	ksi.in^0.5

Thermal properties

Melting point	513	-	522	°F
Maximum service temperature	464	-	482	°F
Minimum service temperature	-459			°F
Thermal conductivity	4.68	-	5.03	BTU.ft/hr.ft^2.°F
Specific heat capacity	0.0275	-	0.031	BTU/lb.°F
Thermal expansion coefficient	7.22	-	7.56	µstrain/°F
Latent heat of fusion	20.6	-	24.1	BTU/lb

Electrical properties

Electrical resistivity	105	-	109	µohm.cm
Galvanic potential	* -0.25	-	-0.17	V

Optical properties

Transparency	Opaque

Magnetic properties

Magnetic type	Non-magnetic

Bio-data

RoHS (EU) compliant grades?	✓
Food contact	No

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Acceptable
Strong acids	Unacceptable
Weak alkalis	Acceptable
Strong alkalis	Limited use
Organic solvents	Excellent

Oxidation at 500C	Unacceptable			
UV radiation (sunlight)	Excellent			
Flammability	Non-flammable			

Primary production energy, CO2 and water

Embodied energy, primary production	* 5.93e4	-	6.53e4	BTU/lb
CO2 footprint, primary production	* 8.63	-	9.51	lb/lb
NOx creation	* 0.0717	-	0.0793	lb/lb
SOx creation	* 0.123	-	0.136	lb/lb
Water usage	* 7.75e4	-	8.55e4	in^3/lb

Processing energy, CO2 footprint & water

Casting energy	* 2.27e3	-	2.5e3	BTU/lb
Casting CO2	* 0.395	-	0.437	lb/lb
Casting water	* 276	-	414	in^3/lb
Rough rolling, forging energy	* 137	-	152	BTU/lb
Rough rolling, forging CO2	* 0.0239	-	0.0265	lb/lb
Rough rolling, forging water	* 46.8	-	70	in^3/lb
Extrusion, foil rolling energy	* 152	-	168	BTU/lb
Extrusion, foil rolling CO2	* 0.0265	-	0.0293	lb/lb
Extrusion, foil rolling water	* 47.1	-	70.6	in^3/lb
Wire drawing energy	* 233	-	258	BTU/lb
Wire drawing CO2	* 0.0407	-	0.045	lb/lb
Wire drawing water	* 5.54	-	8.58	in^3/lb
Metal powder forming energy	* 1.79e3	-	1.99e3	BTU/lb
Metal powder forming CO2	* 0.334	-	0.37	lb/lb
Metal powder forming water	* 126	-	189	in^3/lb
Vaporization energy	* 8.89e5	-	9.83e5	BTU/lb
Vaporization CO2	* 155	-	171	lb/lb
Vaporization water	* 2.39e4	-	3.58e4	in^3/lb
Coarse machining energy (per unit wt removed)	* 206	-	228	BTU/lb
Coarse machining CO2 (per unit wt removed)	* 0.036	-	0.0398	lb/lb
Fine machining energy (per unit wt removed)	* 226	-	250	BTU/lb
Fine machining CO2 (per unit wt removed)	* 0.0395	-	0.0436	lb/lb
Grinding energy (per unit wt removed)	* 248	-	275	BTU/lb
Grinding CO2 (per unit wt removed)	* 0.0433	-	0.0479	lb/lb
Non-conventional machining energy (per unit wt removed)	* 8.89e3	-	9.83e3	BTU/lb
Non-conventional machining CO2 (per unit wt removed)	* 1.55	-	1.71	lb/lb

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 1.09e4	-	1.2e4	BTU/lb
CO2 footprint, recycling	* 1.99	-	2.2	lb/lb
Recycle fraction in current supply	9.59	-	10.6	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✗			
Biodegrade	✗			

Possible substitutes for principal component

Antibiotics, magnesia, and alumina can replace bismuth in pharmaceutical applications. Titanium dioxide-coated mica flakes and fish scale extracts are substitutes in pigment uses. Indium can replace bismuth in low-temperature solders. Resins can replace bismuth alloy jigs used for holding metal shapes during machining. Glycerine-filled glass bulbs can replace bismuth alloys as a triggering device for fire sprinklers. Selenium, tellurium, and lead could replace bismuth in free-machining alloys.

Geo-economic data for principal component

Principal component	Bismuth			
Typical exploited ore grade	0.404	-	0.446	%
Minimum economic ore grade	0.05	-	0.8	%
Abundance in Earth's crust	0.008	-	0.048	ppm
Abundance in seawater	2e-5	-	4e-4	ppm
Annual world production	7.18e3			ton/yr
Reserves	3.15e5			l. ton

Main mining areas (metric tonnes per year)

Bolivia, 10
Canada, 50
China, 6.5e3
Mexico, 940
Other countries, 90

Notes

Warning

Excess bismuth can cause mild kidney damage to humans;

Other notes

Bismuth is one of the less toxic heavy metals. It has a silver luster with a pink tinge.

Links

ProcessUniverse

Producers

Reference

Shape