

Aluminum alloys

The material. Aluminum was once so rare and precious that the Emperor Napoleon III of France had a set of cutlery made from it that cost him more than silver. But that was 1860; today, nearly 150 years later, aluminum spoons are things you throw away—a testament to our ability to be both technically creative and wasteful. Aluminum, the first of the “light alloys” (with magnesium and titanium), is the third most abundant metal in the earth’s crust (after iron and silicon), but extracting it costs much energy. It has grown to be the second most important metal in the economy (steel comes first), and the mainstay of the aerospace industry.

Composition

Al+ alloying elements, e.g., Mg, Mn, Cr, Cu, Zn, Zr, Li

General properties

Density	2,500	—	2,900	kg/m ³
Price	2.4	—	2.7	USD/kg

Mechanical properties

Young’s modulus	68	—	82	GPa
Yield strength (elastic limit)	30	—	550	MPa
Tensile strength	58	—	550	MPa
Elongation	1	—	44	%
Hardness—Vickers	12	—	150	HV
Fatigue strength at 10 ⁷ cycles	22	—	160	MPa
Fracture toughness	22	—	35	MPa · m ^{1/2}

Thermal properties

Melting point	495	—	640	°C
Maximum service temperature	120	—	200	°C
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	76	—	240	W/m · K
Specific heat capacity	860	—	990	J/kg · K
Thermal expansion coefficient	21	—	24	μstrain/°C

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	2.5	—	6	μohm · cm



Cast and wrought aluminum alloys, examples of the wide range of properties of this, the most widely used light alloy

Eco properties: material

Global production, main component	37×10^6			metric ton/yr
Reserves	2.0×10^9			metric ton
Embodied energy, primary production	200	—	220	MJ/kg
CO ₂ footprint, primary production	11	—	13	kg/kg
Water usage	495	—	1,490	L/kg
Eco-indicator	710			millipoints/kg

Eco properties: processing

Casting energy	11	—	12.2	MJ/kg
Casting CO ₂ footprint	0.82	—	0.91	kg/kg
Deformation processing energy	3.3	—	6.8	MJ/kg
Deformation processing CO ₂ footprint	0.19	—	0.23	kg/kg

End of life

Embodied energy, recycling	22	—	30	MJ/kg
CO ₂ footprint, recycling	1.9	—	2.3	kg/kg
Recycle fraction in current supply	41	—	45	%

Typical uses. Aerospace engineering; automotive engineering—pistons, clutch housings, exhaust manifolds; sports equipment such as golf clubs and bicycles; die cast chassis for household and electronic products; siding for buildings; reflecting coatings for mirrors, foil for containers and packaging; beverage cans; electrical and thermal conductors.