

Stainless steel

The material. Stainless steels are alloys of iron with chromium, nickel, and—often—four or five other elements. The alloying transmutes plain carbon steel that rusts and is prone to brittleness below room temperature into a material that does neither. Indeed, most stainless steels resist corrosion in most normal environments, and those that are “austenitic” (like AISI 302, 304, and 316) remain ductile to the lowest of temperatures.

Composition

Fe/ < 0.25 C/16–30 Cr/3.5–37 Ni/ <10 Mn+ Si,P,S (+ N for 200 series)

General properties

Density	7,600	–	8,100	kg/m ³
Price	8.2	–	9.1	USD/kg

Mechanical properties

Young’s modulus	189	–	210	GPa
Yield strength (elastic limit)	170	–	1,000	MPa
Tensile strength	480	–	2,240	MPa
Elongation	5	–	70	%
Hardness—Vickers	130	–	570	HV
Fatigue strength at 10 ⁷ cycles	175	–	753	MPa
Fracture toughness	62	–	150	MPa · m ^{1/2}

Thermal properties

Melting point	1,370	–	1,450	°C
Maximum service temperature	750	–	820	°C
Thermal conductor or insulator?	Poor conductor			
Thermal conductivity	12	–	24	W/m · K
Specific heat capacity	450	–	530	J/kg · K
Thermal expansion coefficient	13	–	20	μstrain/°C

Electrical properties

Electrical conductor or insulator?	Good conductor			
Electrical resistivity	64	–	107	μohm · cm



On the left: Siemens toaster in brushed austenitic stainless steel (by Porsche Design)
On the right: scissors in ferritic stainless steel; it is magnetic, austenitic stainless is not

Eco properties: material

Global production, main component	30×10^6			metric ton/yr
Reserves	2.5×10^9			metric ton
Embodied energy, primary production	81	—	88	MJ/kg
CO ₂ footprint, primary production	4.7	—	5.2	kg/kg
Water usage	112	—	336	L/kg
Eco-indicator	310			millipoints/kg

Eco properties: processing

Casting energy	10.0	—	12.0	MJ/kg
Casting CO ₂ footprint	0.8	—	0.9	kg/kg
Deformation processing energy	5.0	—	11.4	MJ/kg
Deformation processing CO ₂ footprint	0.4	—	0.8	kg/kg

End of life

Embodied energy, recycling	11	—	13	MJ/kg
CO ₂ footprint, recycling	0.65	—	0.8	kg/kg
Recycle fraction in current supply	35	—	40	%

Typical uses. Railway cars, trucks, trailers, food-processing equipment, sinks, stoves, cooking utensils, cutlery, flatware, scissors and knives, architectural metal-work, laundry equipment, chemical-processing equipment, jet-engine parts, surgical tools, furnace and boiler components, oil-burner parts, petroleum-processing equipment, dairy equipment, heat-treating equipment, automotive trim. Structural uses in corrosive environments—for example, nuclear plants, ships, offshore oil installations, underwater cables, and pipes.