

Alloy 600

UNS N06600

Alloy 600 (UNS N06600), a Ni-Cr-Fe high temperature alloy with high nickel content, has excellent resistance to halogens at elevated temperatures and has been used in processes involving chlorination. It has good oxidation and chloride stress corrosion cracking resistance. This alloy has found wide usage in the furnace and heat-treating field due to its excellent resistance to oxidation and scaling at 980 °C. The alloy also has found considerable use in handling water environments, where stainless steels have failed by cracking. It has been used in a number of nuclear reactors including steam generator boiling and primary water piping systems. Alloy 600 has also been used in preheaters and turbine condensers with maximum service temperatures around 450 °C. However, the low chromium content of Alloy 600 prevented its use in applications that required extended exposure to high temperatures and requiring superior creep properties.

Specification

NiWire's production follows:

ASTM B 163 (condenser and heat exchanger tube), B 166 (rod, bar, and wire), B 167 (seamless pipe and tube), B 168 (plate, sheet, and strip), B 366 (welding fittings, permissible raw materials), B 516 (welded tube), B 517 (welded pipe), B 564 (rod), B 751 (welded tube, general requirements), B 775 (welded pipe, general requirements), B 829 (seamless pipe and tube, general requirements)
AMS 5665 (bar, forging), 5540 (sheet, plate, strip), 5687 (wire), 5580 (tube)

Chemical Composition

Composition limits: 72.0 min Ni + Co; 14.0 to 17.0 Cr; 6.0 to 10.0 Fe; 0.15 max C; 1.0 max Mn; 0.015 max S; 0.50 max Si; 0.50 max Cu

Applications

Typical uses: Alloy 600 is used in a variety of applications involving temperatures from cryogenic to 1093 °C (2000 °F). Examples are chemical processing vessels and piping, heat treating equipment, aircraft engine and airframe components, electronic parts, and nuclear reactors.

Physical Properties

Density: 8.42 g/cm³ (0.304 lb/in.³) at 20 °C (68 °F)

Liquidus temperature: 1415 °C (2575 °F)

Solidus temperature: 1355 °C (2470 °F)

Coefficient of thermal expansion: 15.1 μm/m · K (8.4 μin./in. · °F) at 538 °C (1000 °F); 16.4 μm/m · K (9.1 μin./in. · °F) at 871 °C (1600 °F)

Specific heat: 444 J/kg · K (0.103 Btu/lb · °F) at 21 °C (70 °F)

Thermal conductivity: 14.8 W/m · K (103 Btu/ft² · in. · h · °F) at 21 °C (70 °F); 22.8 W/m · K (158 Btu/ft² · in. · h · °F) at 538 °C (1000 °F); 28.8 W/m · K (200 Btu/ft² · in. · h · °F) at 871 °C (1600 °F)

Electrical conductivity: Volumetric, 1.7% IACS at 21 °C (70 °F)

Electrical resistivity: 1030 nΩ · m at 21 °C (70 °F)

Magnetic permeability: 1.010 at a field strength of 15.9 kA/m

Curie temperature: -124 °C (-192 °F)

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Mechanical Properties

Poisson's ratio: 0.29

Elastic modulus: Tension, 207 GPa (30×10^6 psi); torsion, 76 GPa (11×10^6 psi)

Impact strength: Plate, Charpy keyhole: 86.1 J (63.5 ft · lbf) at 21 °C (70 °F); 88.8 J (65.5 ft · lbf) at -79 °C (-110 °F); 82.4 J (60.8 ft · lbf) at -196 °C (-320 °F)

Fatigue strength: Rotating beam: annealed, 269 MPa (39.0 ksi); hot rolled, 279 MPa (40.5 ksi); cold drawn, 310 MPa (45.0 ksi). All values at 108 cycles and 21 °C (70 °F)

Tensile properties for Alloy 600:

Form and condition	Tensile strength		Yield Strength (0.2% offset)		Elongation %
	MPa	ksi	Mpa	ksi	
Rod and bar					
Annealed	552–690	80–100	172–345	25–50	55–35
Hot finished	586–827	85–120	241–621	35–90	50–30
Cold drawn	724–1034	105–150	552–862	80–125	30–10
Plate					
Hot rolled	586–758	85–110	241–448	35–65	50–30
Annealed	552–724	80–105	207–345	30–50	55–35
Sheet					
Annealed	552–690	80–100	207–310	30–45	55–35
Hard	586–1034	120–150	621–862	90–125	15–2
Strip					
Annealed	552–690	80–100	207–310	30–45	55–35
Spring temper	1000–1172	145–170	827–1103	120–160	10–2
Tubing					
Annealed & cold drawn	552–690	80–100	172–345	25–50	55–35
Hot finished	517–690	75–100	172–345	25–50	55–35
Wire					
Annealed	552–827	80–120	241–517	35–75	45–20
Spring temper	1172–1517	107–220	1034–1448	150–210	5–2

Typical tensile and compressive yield strengths of Alloy 600:

Material condition	Tension				Compression			
	0.02% offset		0.2% offset		0.02% offset		0.2% offset	
	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi
Hot rolled and annealed	268	38.9	303	43.9	276	40.0	309	44.8
Cold drawn and stress relieved	552	80.0	619	89.8	513	74.4	605	87.7
As extruded (tubing)	174	25.2	212	30.8	192	27.9	224	32.5

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Typical tensile properties and hardness of Alloy 600:

Form and condition	Tensile strength		Yield strength (0.2% offset)		Elongation %	Hardness
	MPa	ksi	MPa	ksi		
Rod						
As rolled	672	97.5	307	44.5	46	86 HRB
Annealed	624	90.5	210	30.4	49	75 HRB
Plate						
As rolled	682	99.0	346	50.2	42	87 HRB
Annealed	639	92.7	199	28.9	49	75 HRB
Tubing						
As drawn	993	144.0	916	132.8	8	34 HRC
Annealed	693	100.5	279	40.5	43	83 HRB

Typical elevated-temperature tensile properties of Alloy 600 bar

Temperature		Tensile strength		Yield strength		Elongation %
°C	°F	MPa	ksi	MPa	ksi	
21	70	620	90	250	36	47
540	1000	580	84	195	28	47
650	1200	450	65	180	26	39
760	1400	185	27	115	17	46
870	1600	105	15	62	9	80

Typical stress-rupture strengths of Alloy 600

Temperature		For stress rupture at:			
°C	°F	100 h		1000 h	
		MPa	ksi	MPa	ksi
815	1500	55	8	39	5.6
870	1600	37	5.3	24	3.5

Chemical Properties

General corrosion behavior: The high nickel content of Alloy 600 provides good resistance to corrosion under reducing conditions, and its chromium content, resistance under oxidizing conditions. The alloy is virtually immune to chloride stress-corrosion cracking.

Resistance to specific corroding agents: Alloy 600 has useful resistance to many acid solutions, both oxidizing and reducing. This alloy resists dilute hydrochloric acid but not concentrated or hot solutions. It is resistant to all concentrations of phosphoric acid at room temperature. It has poor resistance to nitric acid. Alloy 600 is unaffected by most neutral and alkaline salt solutions and resists many acid salts. It is one of the few materials suitable for use in hot, strong solutions of magnesium chloride, usually having a corrosion rate of about 25 µm(1 mil) per year

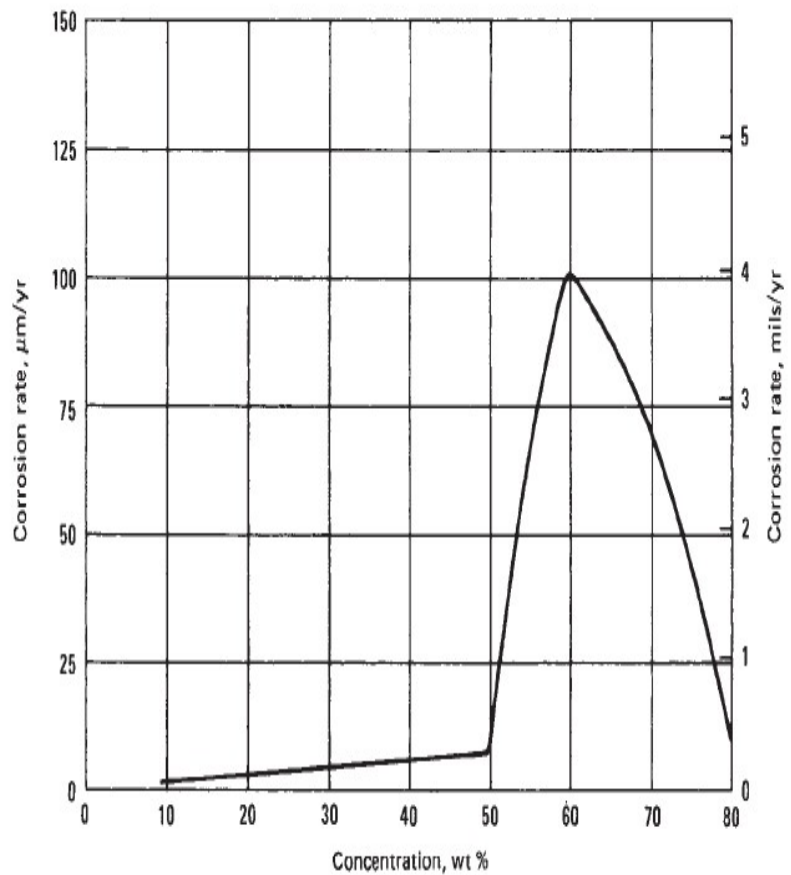
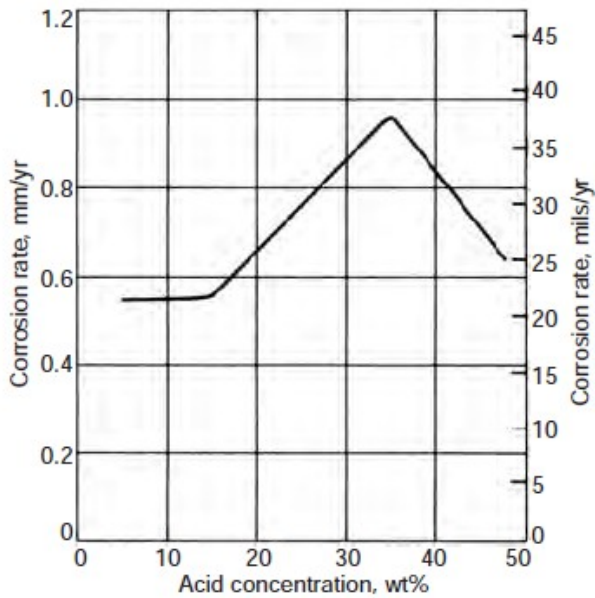
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Corrosion rates for Alloy 600 in various concentrations of sulfuric acid at room temperature and at boiling temperature:

Acid concentration, %	Corrosion rate at			
	Room temperature		Boiling temperature	
	mm/yr	mils/yr	mm/yr	mils/yr
10	0.081	3.2	3.43	135
20	0.051	2.0	4.72	186
30	0.064	2.5	5.49	216
40	0.046	1.8	17.8	700
50	0.041	1.6	...	...
60	0.048	1.9	...	...
70	0.058	2.3	...	...
80	0.566	22.3	...	...
90	0.013	0.5	...	...
98	0.188	7.4	...	...

Corrosion rates for Alloy 600 in hydrofluoric acid at 75 °C (167 °F):



Corrosion rates for Alloy 600 in boiling sodium hydroxide