Alloy 825

NiWire Industries
www.niwire.com

UNS N08825

Alloy 825 (UNS N08825) is a Ni-Cr-Fe-Mo alloy with excellent resistance to sulfuric and phosphoric acids. Resistant to oxidizing and reducing acids, SCC, pitting, and intergranular corrosion, it is used in chemical and petrochemical processing, oil and gas extraction, pollution control, waste processing, and pickling applications

Specification

NiWire's production follows:
ASTM B 163 (condenser and heat exchanger tube), B 366 (welding fittings, permissible raw materials), B 423 (seamless pipe and tube), B 424 (plate, sheet, and strip), B 425 (rod and bar), B 564 (forgings), B 704 (welded tube), B 705 (welded pipe), B 751 (welded tube, general requirements), B 775 (welded pipe, general requirements), B 829 (seamless pipe and tube, general requirements)

Chemical Composition

Composition limits: 38.0 to 46.0 Ni; 19.5 to 23.5 Cr; 2.5 to 3.5 Mo; 1.5 to 3.0 Cu; 0.6 to 1.2 Ti; 0.05 max C; 1.0 max Mn; 0.03 max S; 0.5 max Si; 0.2 max Al; bal Fe

Applications

Typical uses: Phosphoric acid evaporators, pickling equipment, chemical processing vessels and piping, equipment for recovery of spent nuclear fuel, propeller shafts, tank trucks

Physical Properties

Density: 8.14 g/cm3 (0.294 lb/in.3) at 20 °C (68 °F)
Liquidus temperature: 1400 °C (2550 °F)
Solidus temperature: 1370 °C (2500 °F)
Electrical conductivity: Volumetric, 1.5% IACS at 26 °C (78 °F)
Magnetic permeability: 1.005 at 21 °C (70 °F) and a field strength of 15.9 kA/m
Curie temperature: <–196 °C (<–320 °F)

Thermal and electrical properties of Alloy 825:

Temperature		Mean linear expansion(a)		Thermal conductivity		Electrical resistivity
°C	°F	µm/m · K	µin./in. · °F	W/m · K	Btu/ft · h · °F	nΩ · m
26	78	...	...	11.1	6.4	1127
38	100	...	...	11.3	6.5	1130
93	200	14.0	7.7	12.3	7.1	1142
204	400	14.9	8.3	14.1	8.1	1180
316	600	15.3	8.5	15.8	9.1	1210
427	800	15.7	8.7	17.3	10.0	1248
538	1000	15.8	8.8	18.9	10.9	1265
649	1200	16.4	9.1	20.5	11.8	1267
760	1400	17.1	9.5	22.3	12.9	1272
871	1600	17.5	9.7	24.8	14.3	1288
982	1800	...	...	27.7	16.0	1300

(a) From 27 °C (80 °F) to temperature shown

Alloy 825

NiWire Industries
www.niwire.com

UNS N08825

Mechanical Properties

Compressive properties: Annealed bar with tensile yield strength of 396 MPa (57.5 ksi): compressive yield strength, 423 MPa (61.4 ksi) at 0.2% offset
Elastic modulus: Tension, 195 GPa (28.3 · 106 psi) at 27 °C (80 °F)
Impact strength: Plate, Charpy keyhole: 107 J (78.9 ft · lbf) at 20 °C (68 °F); 106 J (78.2 ft · lbf) at –79 °C (–110 °F); 91 J (67.1 ft · lbf) at –196 °C (–320 °F); 92 J (67.8 ft · lbf) at –253 °C (–420 °F)

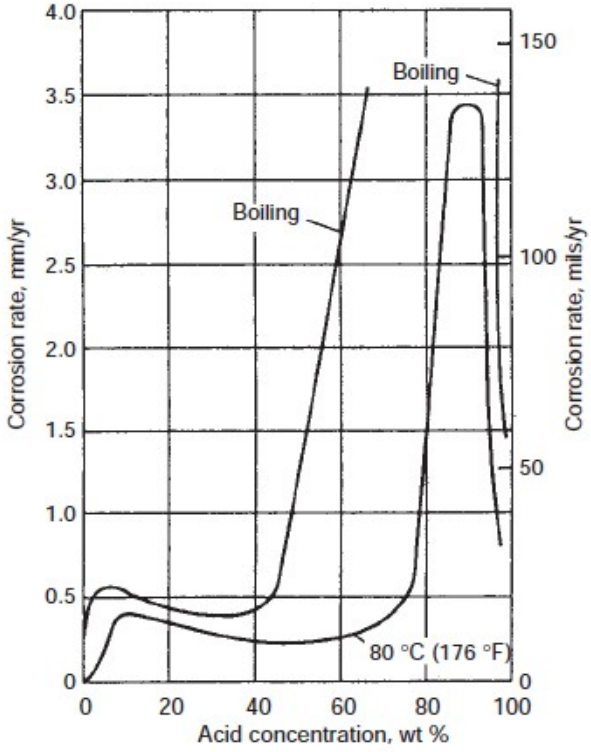
Tensile properties of annealed Alloy 825:

Temperature		Tensile strength		Yield strength (0.2 offset)		Elongation
°C	°F	MPa	ksi	MPa	ksi	%
29	85	693	100.5	301	43.7	43
93	200	655	95.0	279	40.4	44
204	400	637	92.4	245	35.6	43
316	600	632	91.7	232	33.6	46
371	700	621	90.0	234	34.0	46
427	800	610	88.5	228	33.0	44
482	900	608	88.2	221	32.0	42
538	1000	592	85.9	229	33.2	43
593	1100	541	78.5	222	32.2	38
649	1200	465	67.5	213	30.9	62
760	1400	274	39.7	183	26.5	87
871	1600	135	19.6	117	17.0	102
982	1800	75	10.9	47	6.8	173
1093	2000	42	6.1	23	3.3	106

Chemical Properties

General corrosion behavior: Alloy 825 has exceptional resistance to seawater and to reducing chemicals, such as sulfuric and phosphoric acids. Because it is stabilized against sensitization, Alloy 825 resists intergranular corrosion. This alloy contains sufficient nickel to make it resistant to chloride stress-corrosion cracking. Its molybdenum content provides resistance to pitting. Its chromium content provides resistance to oxidizing media, such as nitric acid, nitrates, and oxidizing salts.

Laboratory corrosion rates of Alloy 825 in chemically pure sulfuric acid solutions, see right figure.



Alloy 825

UNS N08825

Plant corrosion tests of Alloy 825 immersed in wet-process phosphoric acid solutions:

Test solution	Temperature		Duration of test, days	Corrosion rate	
	°C	°F		mm/yr	mils/yr
Recycle liquor from evaporator fume scrubber containing 15% H_3PO_4, 20% H_2SiF_6, 1% H_2SO_4	75–85	165–185	16	0.025	1.0
Solution containing 20% H_3PO_4 and 20% HF in tank	20–30	70–85	13	0.036	1.4
Slurry in digester tank. Mixture contains 20% H_3PO_4, 2% H_2SO_4, 1% HF, 40% H_2O, plus $CaSO_4$	75–95	170–200	117	0.02	0.7
Slurry containing 37% H_3PO_4 (27% P_2O_5) in acid transfer tank. Velocity 1 m/s (3 ft/s)	65–90	150–190	46	0.02	0.7
Slurry containing 31.4% H_3PO_4, 1.6% H_2SO_4, 1.5% H_2SiF_6, 0.12% HF, plus $CaSO_4$ in filter tank	45–60	115–140	8.3	<0.003	<0.1
Thickener in evaporated acid containing 54% H_3PO_4, 1.7% HF, 2% H_2SO_4, 2% $CaSO_4$	50–65	125–150	51	0.01	0.5
Evaporator heated with hot gases in acid containing 53% H_3PO_4, 1–2% H_3SO_4, 1.5% HF plus Na_2SiF_6	120	250	42	0.15	6.0
In wet separator on top of concentrating drum in vapors from concentration of crude acid to 50–55% H_3PO_4 containing HF	105–150	225–300	21	0.79	31.0
Defluorinator in acid containing 75–80% H_3PO_4, 1% H_2SO_4, with some HF. Violent agitation	120–155	250–315	8	3.048	120.0

Corrosion rates for Alloy 825 in hydrochloric acid at three temperatures:

Acid concentration, %	Temperature		Corrosion rate	
	°C	°F	mm/yr	mils/yr
5	20	68	0.12	4.9
	40	104	0.45	17.8
	66	150	2.00	79
10	20	68	0.18	7.2
	40	104	0.47	18.6
	66	150	2.60	102
20	20	68	0.18(a)	7.3(a)
	40	104	0.44	17.2
	66	150	1.52	60

(a) 15% acid concentration

Alloy 825

UNS N08825

Plant corrosion tests of Alloy 825 in nitric acid mixtures:

Test conditions (a)	Temperature		Duration of test, days	Corrosion rate	
	°C	°F		mm/yr	mils/yr
In evaporator during concentration of nitric acid solution saturated with potassium nitrate and containing chlorides					
Liquid: 40–70% HNO_3, 0.2–0.02% Cl	105–115	220–240	4.2	0.10	4.0
Vapor: 50–10% HNO_3, 0.05–1.5% Cl	105–115	220–240	4.2	0.279	11.0
In evaporator during concentration of nitric acid solution from 35–45% nitric acid, saturated with zirconyl nitrate and containing 10–35% $ZrO(NO_3)_2$ crystals					
Liquid	115–125	235–255	29	0.533	21.0
Vapor	115–125	235–255	29	0.660	26.0
In 40% nitric acid solution containing some nitrogen tetroxide and nitrous acid. Location in N_2O_2 absorption tower immediately below distributor	30–40	85–105	15	<0.003	<0.1
In evaporator during concentration of 20% nitric acid solution containing 6% metal nitrates (iron, magnesium, lead and aluminum), 2% sulfate as metal sulfates	70–90	160–190	52	0.01	0.4
Laboratory test in 53% nitric acid containing 1% hydrofluoric acid					
Liquid	80	176	7	5.080	200.0
Vapor	80	176	7	2.18	86.0
In vapor during concentration of nitric acid solution containing 35–45% nitric acid, 3–20% chlorine as chlorides, and 10–20% metal nitrates (mainly zirconium)					
Liquid	115–125	240–260	21	0.330	13.0
Vapor	115–125	240–260	21	0.15	5.8
In evaporator during concentration of 36% nitric acid solution containing 30% potassium nitrate, some sodium, iron, calcium and magnesium nitrates, and 0.05–0.10% chlorine as chloride. Intermittently exposed to liquid and vapor	65–80	150–180	8	0.01	0.5
In evaporator during concentration of nitric acid solution containing metal nitrates (mostly zirconium) and small amount of chlorides					
Liquid at bottom of column (58% nitric acid, 5 ppm chlorides, 11–13% metal nitrates)	115–130	240–265	10	0.660	26.0
Liquid on 10th tray of column (2.21% nitric acid, 3–13 ppm chlorides, 0–25% metal nitrates)	105–130	225–265	10	0.12	4.6

Continued

Test conditions (a)	Temperature °C	Temperature °F	Duration of test, days	Corrosion rate mm/yr	Corrosion rate mils/yr
In evaporator during concentration of raffinate solution containing 30–40% nitric acid and variable chlorides up to 2000 ppm Cl					
Liquid	80(b)	175(b)	92	0.02	0.7
Vapor	80(b)	175(b)	92	0.028	1.1

(a) Specimens were immersed in solution unless otherwise stated. (b) Average

Plant corrosion tests of Alloy 825 in organic acids:

Test conditions	Temperature °C	Temperature °F	Duration of test, days	Corrosion rate mm/yr	Corrosion rate mils/yr
In vapors of 85% acetic acid, 10% acetic anhydride, 5% water, plus some acetone, acetonitrile, in vapor line just before condenser	115–135	240–275	875	0.008	0.3
In 99.9% acetic acid, less than 0.1% water in still	105	225	40	0.006	0.2
In mixture of 94% acetic acid, 1% formic acid, 5% high boiling esters	125	260	465	0.02	0.7
In mixture of 96.5–98% acetic acid, 1.5% formic acid, 1–1.5% water	125	255	262	0.15	6.0
In mixture of 91.5% acetic acid, 2.5% formic acid, 6.0% water	110–125	230–260	55	0.079	3.1
In mixture of 95% acetic acid, 1.5–3.0% formic acid, 0.5% potassium permanganate, balance water	110–145	230–290	55	0.038	1.5
In mixture of 40% acetic acid, 6% propionic acid, 20% butane, 5% pentane, 8% ethyl acetate, 5% methyl ethyl ketone, plus other esters and ketones	175	345	217	0.051	2.0
In liquid phthalic anhydride containing phthalic acid, some water, and small amounts of maleic acid, maleic anhydride, benzoic acid, and napthaquinones. On reflux plate of crude phthalic anhydride still	165–260	330–500	70	0.20	8.0