Specification Sheet: Alloy 625
(UNS N06625) W. Nr. 2.4856

An Austenitic Nickel-Chromium-Molybdenum-Niobium Alloy with Outstanding Corrosion Resistance and High Strength from Cryogenic Temperatures to 1800°F (982°C)

Alloy 625 is an austenitic nickel-chromium-molybdenum-niobium alloy possessing a rare combination of outstanding corrosion resistance coupled with high strength from cryogenic temperatures to 1800°F (982°C).

The strength of Alloy 625 is derived from the solid-solution hardening of the nickel-chromium matrix by the presence of molybdenum and niobium. Therefore, precipitation-hardening treatments are not required.

The chemical composition of Alloy 625 is also responsible for its outstanding corrosion resistance in a variety of severe operating environments along with resistance to oxidation and carburization in high temperature service. The alloy is resistant to pitting, crevice corrosion, impingement corrosion, intergranular attack and is almost immune to chloride stress corrosion cracking.

Alloy 625 can be easily welded and processed by standard shop fabrication practices.

Standards

ASTM .... B 443
ASME .... SB 443
AMS 5599

Oxidation Resistance

The oxidation and scaling resistance of Alloy 625 is superior to a number of heat resistant austenitic stainless steels such as 304, 309, 310 and 347 up to 1800°F (982°C) and under cyclic heating and cooling conditions. Above 1800°F (982°C), scaling can become a restrictive factor in service.

Applications

- Aerospace Components — bellows and expansion joints, ducting systems, jet engine exhaust systems, engine thrust-reversers, turbine shroud rings
- Air Pollution Control — chimney liners, dampers, flue gas desulfurization (FGD) components
- Chemical Processing — equipment handling both oxidizing and reducing acids, super-phosphoric acid production
- Marine Service — steam line bellows, Navy ship exhaust systems, submarine auxiliary propulsion systems
- Nuclear Industry — reactor core and control rod components, waste reprocessing equipment
- Offshore Oil and Gas Production — waste flare gas stacks, piping systems, riser sheathing, sour gas piping and tubing
- Petroleum Refining — waste flare gas stacks
- Waste Treatment — waste incineration components

Chemical Analysis

Weight % (all values are maximum unless a range is otherwise indicated)

Nickel	58.0 min.	**Silicon**	0.50
Chromium	20.0 min.–23.0 max.	**Phosphorus**	0.015
Molybdenum	8.0 min.–10.0 max.	**Sulfur**	0.015
Iron	5.0	**Aluminum**	0.40
Niobium (plus Tantalum)	3.15 min.–4.15 max.	**Titanium**	0.40
Carbon	0.10	**Cobalt (if determined)**	1.0
Manganese	0.50		

Mechanical Properties

Typical Values at 68°F (20°C)

Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation in 2 in.	Hardness
psi	(MPa)	psi	(MPa)	%	
65,000	448	125,000	862	50	200 Brinell

Physical Properties

Density
0.305 lbs/in³
8.44 g/cm³

Modulus of Elasticity
30.1 x 10^6 psi
207.5 GPa

Melting Range
2350–2460°F
1290–1350°C

Specific Heat
0.102 BTU/lb-°F (32–212°F)
427 J/kg-°C (0–100°C)

Thermal Conductivity 212°F (100°C)
75 BTU-in/ft²-h-°F
10.8 W/m-°C

Electrical Resistivity
50.8 Microhm-in at 70°F
128.9 Microhm-cm at 21°C

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Mean Coefficient of Thermal Expansion

Temperature Range °F	Temperature Range °C	in/in/°F	cm/cm °C
200	93	7.1 x 10^{-6}	12.8 x 10^{-6}
400	204	7.3 x 10^{-6}	13.1 x 10^{-6}
600	316	7.4 x 10^{-6}	13.3 x 10^{-6}
800	427	7.6 x 10^{-6}	13.7 x 10^{-6}
1000	538	7.8 x 10^{-6}	14.0 x 10^{-6}
1200	649	8.2 x 10^{-6}	14.8 x 10^{-6}
1400	760	8.5 x 10^{-6}	15.3 x 10^{-6}
1600	871	8.8 x 10^{-6}	15.8 x 10^{-6}
1700	927	9.0 x 10^{-6}	16.2 x 10^{-6}

Corrosion Resistance

The highly alloyed chemical composition of Alloy 625 imparts outstanding corrosion resistance in a variety of severely corrosive environments. The alloy is virtually immune to attack in mild conditions such as the atmosphere, fresh and sea water, neutral salts and alkaline solutions. Nickel and chromium provide resistance to oxidizing solutions and the combination of nickel and molybdenum supply resistance in non-oxidizing environments. Molybdenum also makes Alloy 625 resistant to pitting and crevice corrosion, while niobium acts as a stabilizer during welding to prevent intergranular cracking. The high nickel content of Alloy 625 makes it virtually immune to chloride stress corrosion cracking.

The alloy resists attack by mineral acids such as hydrochloric, nitric, phosphoric and sulfuric, and to alkalis and organic acids in both oxidizing and reducing conditions.

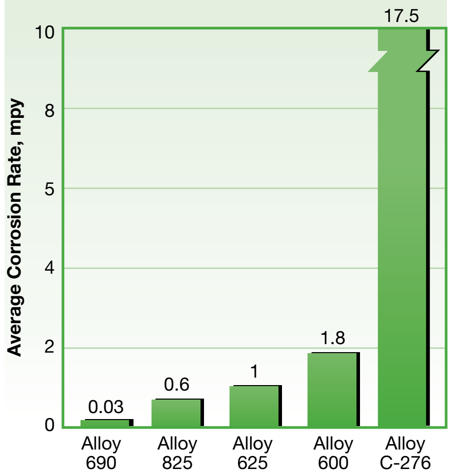
Resistance of Nickel Alloys to Impingement Attack by Seawater at 150 ft/sec (45.7 m/s)

ALLOY	Corrosion/Erosion Rate	
	mpy	mm/a
Alloy 625	Nil	Nil
Alloy 825	0.3	0.008
Alloy K-500	0.4	0.01
Alloy 400	0.4	0.01
Nickel 200	40	1.0

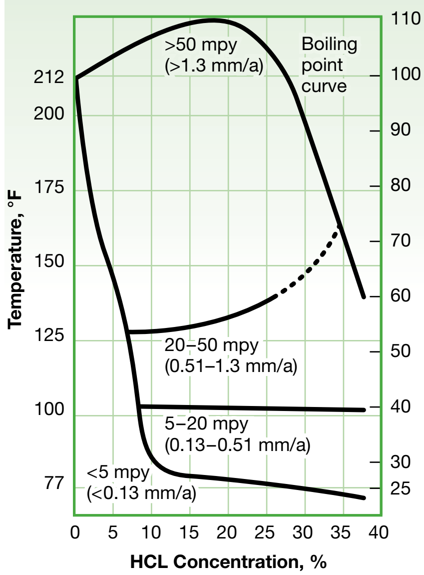
Corrosion-Resistance of Nickel Alloys in Four 24-hour Tests in Boiling Acetic Acid

ALLOY	Acetic Acid Concentration	Corrosion/Erosion Rate	
		mpy	mm/a
Alloy 825	10%	0.60–0.63	0.0152–0.160
Alloy 625	10%	0.39–0.77	0.01–0.019
Alloy C-276	10%	0.41–0.45	0.011–0.0114
Alloy 686	80%	<0.1*	<0.01*

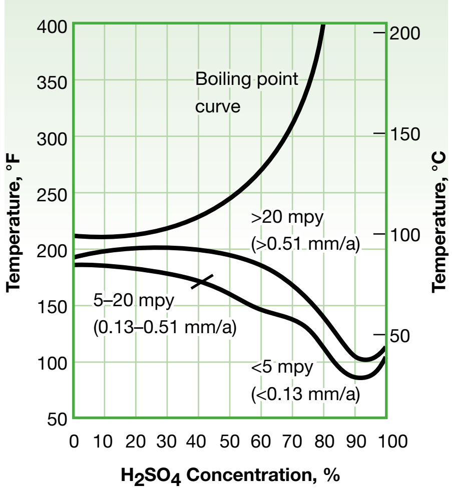
Average corrosion rates for nickel alloys in 10% nitric acid at boiling temperatures.



Iso-corrosion chart for Alloy 625 in hydrochloric acid.



Iso-corrosion chart for Alloy 625 in sulfuric acid.



The comparative PREN number for Alloy 625 is shown in the table below.

Pitting Resistance Equivalency Numbers (PREN)* for Corrosion-Resistant Alloys

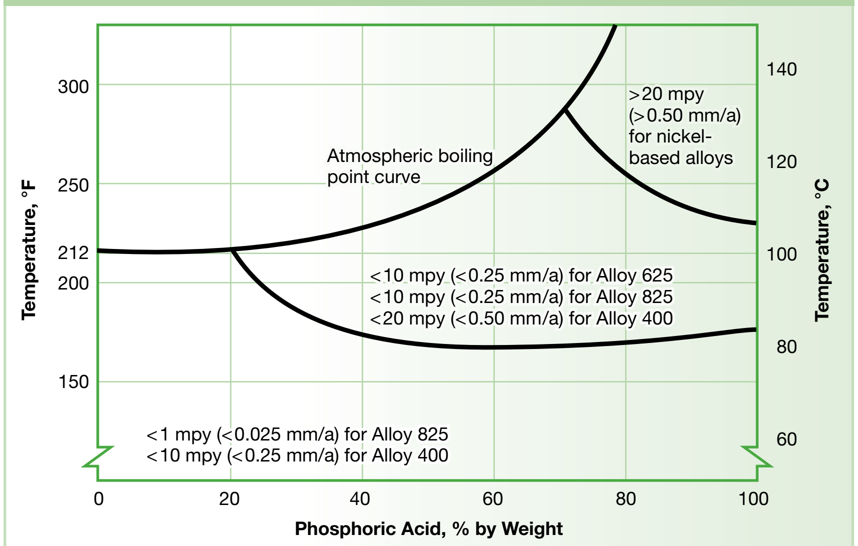
ALLOY	Ni	Cr	Mo	W	Nb	N	PREN
316 Stainless Steel	12	17	2.2	—	—	—	20.4
317 Stainless Steel	13	18	3.8	—	—	—	23.7
Alloy 825	42	21.5	3	—	—	—	26.0
Alloy 864	34	21	4.3	—	-—	—	27.4
Alloy G-3	44	22	7	—	—	—	32.5
Alloy 625	62	22	9	—	3.5	—	40.8
Alloy C-276	58	16	16	3.5	—	—	45.2
Alloy 622	60	20.5	14	3.5	—	—	46.8
SSC-6MO	24	21	6.2	—	—	0.22	48.0
Alloy 686	58	20.5	16.3	3.5	—	—	50.8

* (PREN) = *%CR + 1.5 (%Mo + %W + %Nb) + 30 (%N)*

Corrosion-Resistance of Nickel Alloys in 24-hour Tests in Boiling 40% Formic Acid

ALLOY	Corrosion Rate	
	mpy	mm/a
Alloy 825	7.9	0.2
Nickel 200	10.3–10.5	0.26–0.27
Alloy 400	1.5–2.7	0.038–0.068
Alloy 600	10.0	0.25
Alloy G-3	1.8–2.1	0.046–0.05
Alloy 625	6.8–7.8	0.17–0.19
Alloy C-276	2.8–2.9	0.07–0.074

Material selection chart for nickel alloys in pure phosphoric acid.



Fabrication Data

Alloy 625 can be easily welded and processed by standard shop fabrication practices, however because the high strength of the alloy, it resists deformation at hot-working temperatures.

Hot Forming

The hot-working temperature range for Alloy 625 is 1650–2150°F (900–1177°C). Heavy working needs to occur as close to 2150°F (1177°C) as possible, while lighter working can take place down to 1700°F (927°C). Hot-working should occur in uniform reductions to prevent duplex grain structure

Cold Forming

Alloy 625 can be cold-formed by the standard shop fabrication practices. The alloy should be in the annealed condition. Work hardening rates are higher than the austenitic stainless steels.

Welding

Alloy 625 can be readily welded by most standard processes including GTAW (TIG), PLASMA, GMAW (MIG/MAG), SAW and SMAW (MMA). A post weld heat treatment is not necessary. Brushing with a stainless steel wire brush after welding will remove the heat tint and produce a surface area that does not require additional pickling.

Machining

Alloy 625 should preferably be machined in the annealed condition. Since Alloy 625 is prone to work-hardening, only low cutting speeds should be used and the cutting tool should be engaged at all times. Adequate cut depth is necessary to assure avoiding contact with the previously formed work-hardened zone.

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