Specification Sheet: Alloy 400/Alloy 400AR
(UNS N04400) / W.Nr. 2.4360 and 2.4361

A Nickel-Copper Alloy with Resistance to a Variety of Corrosive Conditions

Alloy 400 (UNS N04400) is a nickel-copper alloy with excellent resistance to a wide range of corrosive environments. It is resistant to chloride stress corrosion cracking and has high strength and toughness over a wide range of temperatures.

The alloy is used extensively in many corrosive applications especially in the marine and chemical processing industries. Alloy 400 is readily fabricated by conventional processing operations.

Alloy 400AR is produced in the as-rolled condition to meet higher strength requirements.

Applications

- Chemical Processing Equipment — in fluorine, hydrofluoric acid, hydrogen fluoride, hydrochloric acid, sulfuric acid, neutral and alkaline salt solutions, caustic alkalies, non-oxidizing halides and dry chlorine service.
- Marine Components — shipbuilding valves, pumps, shafts and in sea and brackish water
- Oil and Gas Production — splash-zones for offshore structures and sour gas applications
- Ore Processing — uranium refining and separation in the production of nuclear fuels
- Petroleum Refining — alkylation units, crude petroleum stills, piping and storage tanks
- Power Generation — feed-water heaters and steam generators
- Water Treatment — brine heaters and evaporators in seawater desalination plants

Standards

ASTM .....B 127
ASME.....SB 127
AMS 4544
Federal QQ-N-281

Chemical Analysis

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

Nickel (plus Cobalt)	63.0 min.–70.0 max.	**Iron**	2.50
Copper	28.0 min.–34.0 max.	**Sulfur**	0.024
Carbon	0.3	**Silicon**	0.5
Manganese	2.0		

Physical Properties

Density
0.318 lb/in^3
8.80 g/cm^3

Specific Heat
0.102 BTU/lb-°F (68°F)
427 J/kg-°K (20°C)

Electrical Resistivity
307 Microhm-ft at 70°F
0.511 Microhm-m at 21°C

Modulus of Elasticity
26.4 x 10^3 ksi (68°F)
182 GPa (20°C)

Melting Range
2370–2460°F
1300–1350°C

Thermal Conductivity
150 BTU/hr/ft^2/ft/°F (68°F)
22.0 W/m-°K (20°C)

Mean Linear Expansion

Temperature		Mean Linear Expansion[a]	
°F	°C	in/in/°F x 10^{-6}	µm/m•°C
-320	-200	—	—
-300	-180	6.1	11.1
-200	-130	6.4	11.4
-100	-70	6.7	12.1
70	21	—	—
200	100	7.7	14.2
400	200	8.6	15.2
600	300	8.8	15.7
800	400	8.9	16.1
1000	500	9.1	16.3
1200	600	9.3	16.6
1400	700	9.6	17.0
1600	800	9.8	17.4
1800	900	10.0[b]	17.7
2000	1000	10.3[b]	18.1[b]

(a) annealed material, (b) extrapolated

Mechanical Properties

Nominal Room-Temperature Mechanical Properties of Alloy 400 and AlloyAR

FORM AND CONDITION	Yield Strength 0.2% Offset		Tensile Strength		Elongation, %	Hardness	
	ksi	MPa	ksi	MPa		Brinell (3000-kg)	Rockwell B
Plate							
Hot-Rolled, As-Rolled	40–75	276–517	75–95	517–655	45–30	125–215	70–96
Hot-Rolled, Annealed	28–50	193–345	70–85	482–586	50–35	110–140	60–76

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Corrosion Resistance

Alloy 400 is a very versatile corrosion resistant material. It exhibits resistance to corrosion in many reducing environments, and it is generally more resistant than higher copper alloys to oxidizing media. Alloy 400 is one of the few materials that will withstand contact with fluorine, hydrofluoric acid, hydrogen fluoride or their derivatives. The alloy has been found to offer exceptional resistance to hydrofluoric acid in all concentrations up to the boiling point. Alloy 400 also resists sulfuric and hydrochloric acids under reducing conditions. It has outstanding resistance to neutral and alkaline salts and has been utilized for many years as a material of construction for salt plants.

Alloy 400 is one of the most widely used materials for marine applications, shipbuilding and seawater desalination plants. The alloy exhibits very low rates of corrosion in flowing sea or brackish water. However, under stagnant conditions, the alloy can encounter crevice and pitting corrosion. Alloy 400 resists stress corrosion cracking and pitting in most fresh and industrial water applications.

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

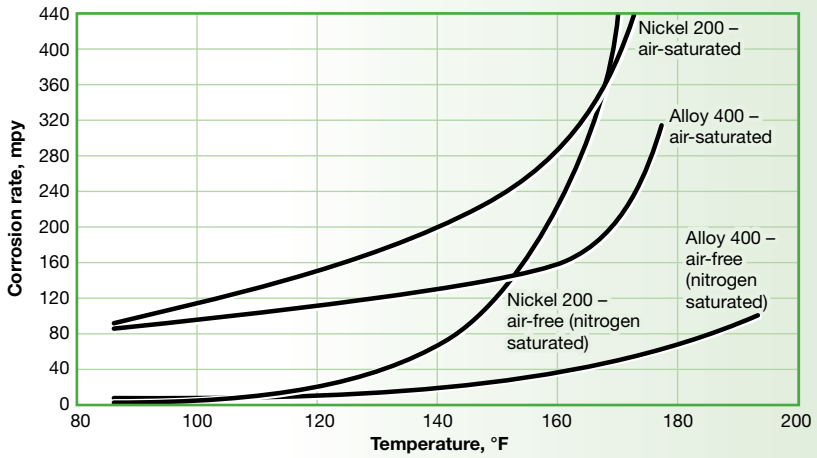
Plant corrosion tests in the storage of commercial 60-65% hydrofluoric acid[a]

MATERIAL	Corrosion Rate, mpy (mm/a)
Alloy 400	22 (0.56)
Nickel 200	>200 (>5.08)[b]
Alloy 600	150 (3.81)
AISI 304 Stainless Steel	>210 (>5.33)[b]
AISI 316 Stainless Steel	>190 (>4.83)[b]
Mild Steel	170 (4.32)

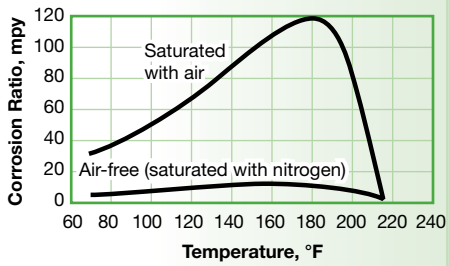
(a) *Acid contains 1.5–2.5% fluosilicic acid, 0.3–1.25% sulfuric acid, and 0.01–0.03% iron. Test specimens immersed in solution in storage tank. Temperature, 60–80°F (15–27°C); duration of test, 28 days.*

(b) *Specimen completely destroyed during test.*

Effect of temperature on corrosion of Nickel 200 and Alloy 400 in 5% hydrochloric acid.



Effect of temperature on corrosion of Alloy 400 in sulfuric acid. Acid concentration, 5–6%. Velocity, 15.5–16.5 ft/min.



Fabrication Data

Alloy 400 is readily fabricated by conventional processing operations.

Hot Working

Alloy 400 is a relatively soft material that is receptive to hot forming into almost any shape. The range of hot forming temperatures is 1200–2150°F (649–1177°C). For heavy reductions the recommended temperature range is 1700–2150°F (927–1177°C). Light reductions are possible with temperatures as low as 1200°F (649°C). Working at lower temperatures will result in higher mechanical properties and smaller grain size.

Cold Working

Alloy 400 is readily cold worked by virtually all cold fabrication methods. Cold working should be performed on annealed material. The alloy has a somewhat higher work hardening rate than carbon steel, but not as high as 304 stainless steel.

Machining

Alloy 400 can be machined at standard rates with conventional machine tools. Surface cutting speeds should be low compared to those used for carbon steel due to the alloy's high work-hardening rate.

Welding

Alloy 400 can be welded to itself or dissimilar metals by utilizing conventional welding processes. These include conventional or hot wire GTAW (TIG), plasma arc, GMAW (MIG/MAG) and SMAW (MMA). The choice of welding product is dependent upon the materials being welded and the environment in which it occurs.

SANDMEYER STEEL COMPANY