

NI-CU 400

Applicable specifications: AMS 7233C, ASTM B164, QQ-N-281D
Associated identifier: UNS N04400

Type analysis

Single figures are nominal except where noted.

Nickel	63.00–70.00 %	Copper	Balance	Iron	Max 2.50 %
Manganese	Max 2.00 %	Silicon	Max 0.50 %	Carbon	Max 0.30 %
Sulfur	Max 0.024 %				

Forms manufactured

Bar-Rounds	Billet	Wire
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Description

Ni-Cu 400 is a solid solution binary alloy of nickel and copper combining high strength (comparable to structural steel) and toughness over a wide temperature range with excellent resistance to many corrosive environments. Used at temperatures up to 800°F (427°C) and as high as 1000°F (538°C) in sulfur-free oxidizing atmospheres, it also displays excellent mechanical properties at sub-zero temperatures since it does not undergo a ductile-to-brittle transition even at such temperatures. The alloy is strengthened by cold work and is readily fabricated.

Ni-Cu 400 has been widely used in many applications:

- Marine: Pump shafts, propellers, fasteners, fixtures
- Chemical processing: Heat exchangers, process vessels, piping
- Energy: Crude petroleum stills, feedwater heaters
- Industrial: Tanks, valves, corrosion-resistant hardware

Key Properties:

- High strength and toughness across temperature ranges, from cryogenic temperatures to elevated temperatures
- Excellent corrosion resistance
- Strengthened only by cold work, not heat treatment
- Superior resistance to reducing environments and seawater

Markets:

- Aerospace
- Consumer
- Defense
- Energy
- Industrial

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Corrosion resistance

Ni-Cu 400 exhibits its best corrosion resistance in reducing and neutral environments. Ni-Cu 400 is virtually immune to chloride ion stress corrosion cracking in typical environments. Generally, its corrosion resistance is very good in reducing environments, but poor in oxidizing conditions. The alloy is resistant to most alkalis, salts, waters (including saline or brackish), food products, organic substances, and atmospheric conditions at normal and elevated temperatures.

Ni-Cu 400 is not useful in highly oxidizing acids, such as nitric and nitrous. It is resistant to sulfuric acid in concentrations to 80% and in hydrochloric solutions in concentrations to 20%. Oxidizing impurities such as ferric chloride, ferric sulfate, chromates, nitrates, peroxides, and cupric salts can cause attack in a medium that would otherwise be relatively mild.

IMPORTANT NOTE:

The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors that affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish, and dissimilar metal contact.

Sodium Hydroxide	Excellent	Salt Spray (NaCl)	Moderate
Sea Water	Moderate	Sour Oil/Gas	Moderate
Humidity	Good		

Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	8.84	8.84
DENSITY	—	0.3190 lb/in ³	—
MEAN SPECIFIC HEAT	32 to 212°F (0 to 100°C)	0.1020 Btu/lb/°F	—
MEAN COEFFICIENT OF THERMAL EXPANSION	70 to 200°F (21 to 93°C)	7.70 x 10 ⁻⁶ in/in/°F	—
THERMAL CONDUCTIVITY	68°F (20°C)	151.0 Btu-in/hr/ft ² /°F	—
ELASTIC MODULUS			
IN TORSION	—	10.0 x 10 ³ ksi	—
IN TENSION	—	26.0 x 10 ³ ksi	—
ELECTRICAL RESISTIVITY	68°F (20°C)	307.0 ohm-cir-mil/ft	—
MELTING RANGE		2460°F	1349°C

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Typical mechanical properties

Ni-Cu 400 is commonly supplied in hot worked, annealed, or stress relieved conditions, depending on required strength and formability. Mechanical properties may be tailored through controlled cold work. The alloy is strengthened by solid-solution strengthening and cold work. It is not precipitation hardenable.

ROOM TEMPERATURE									
CONDITION			0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION	REDUCTION OF AREA	HARDNESS
°F	°C	HOURS	ksi	MPa	ksi	MPa	%	%	HRB
Hot rolled			43	297	82	565	52	83	77
Annealed, 0.312 in. round									
1600	871	0.5	30	207	75	517	55	86	64
1650	899	0.5	28	193	74	510	56	88	63
1700	927	0.5	27	186	70	483	41	85	60
1750	954	0.5	25	172	68	469	42	87	60
1800	982	0.5	23	159	65	448	41	90	59
Stress Relieved, 0.312 in. round									
1000	538	1	43	297	82	565	53	82	75
1000	538	2	50	345	83	572	51	82	75
1050	566	1	42	290	81	559	54	82	76
1050	566	2	43	297	81	559	52	83	76

Heat treatment

Both cold worked and hot worked Ni-Cu 400 may be annealed or stress relieved for the desired combination of strength and ductility and to minimize distortion during subsequent machining.

Annealing	Heating should be done in a sulfur-free reducing atmosphere. The annealing range is 1300 to 1800°F (704 to 982°C), however 1600 to 1800°F (871 to 982°C) is most typical. The lower annealing temperatures (e.g., 1300 to 1500°F [740 to 816°C]) can be utilized with longer times at temperature to minimize grain coarsening.
Stress relieving	Stress relieving will reduce stresses without recrystallizing the grain structure. Heating to 1000/1050°F (538/566°C) for 1 to 2 hours will relieve strains in either hot or cold worked products.

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Workability

Hot working	Ni-Cu 400 is readily hot worked from 1700°F (927°C) to 2150°F (1177°C). Optimum working temperature is approximately 2000°F (1093°C). Finished fabrications can be produced to a rather wide range of mechanical properties by proper control of the amount of hot and/or cold work and by the selection of proper thermal treatments.
Cold working	Ni-Cu 400 is readily cold worked. Finished fabrications can be produced to a rather wide range of mechanical properties by proper control of the amount cold work and by the selection of proper thermal treatments. See the table below.
Machinability	Ni-Cu 400 can be machined at satisfactory rates with machine tools generally employed by industry. Generally, cold drawn or cold drawn-stress relieved material is suggested for best machinability and smoothest finish.
Joining	Ni-Cu 400 can be welded, brazed, or soldered. Gas or electric welding methods can be employed. When gas welding, the flame must be close to neutral (on the reducing side), and the work must be done rapidly without rewelding.

EFFECTS OF COLD WORK ON ROOM TEMPERATURE TENSILE PROPERTIES, 0.250 IN. ROUND

CONDITION	COLD WORK	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION	REDUCTION OF AREA
	%	ksi	MPa	ksi	MPa	%	%
Unannealed	0	40	276	82	565	54	80
	5	80	552	89	614	39	79
	10	85	586	95	655	35	80
	15	95	655	103	710	25	78
	20	101	696	110	758	20	79
	30	116	800	121	834	21	73
	40	126	869	131	903	18	72
Annealed 1733°F (945°C) 0.5 hr, water quenched, reducing atmosphere	0	25	172	72	496	57	82
	5	69	476	81	559	42	79
	10	74	510	83	572	37	82
	15	85	586	90	621	30	83
	20	92	634	99	683	23	86
	30	105	724	111	765	21	82
	40	112	772	117	807	19	79

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