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CuNi2Si

UNS:C70260, C64700
EN:CW111C

CuNi2Si are a precipitation hardening copper alloys. It has high mechanical and electrical properties. In the artificial aged temper, the alloy exhibits high strength and hardness, good wear resistance and fatigue resistance, high corrosion resistance, high electrical and thermal conductivity. This alloy has excellent hot forming. Cold working before precipitation hardening can further improve strength and hardness.

Basic properties

Basic properties	Value	Comments
Density [g/cm^3]	8,8-8,9	
Specific heat capacity [J/(kg*K)]	377	
Temperature coefficient of electrical resistance (0...100°C) [10^{-3}/K]	2	
Electrical conductivity [T=20°C, (% IACS)]	25-51	
Thermal conductivity [W/(m*K)]	150-250	
Thermal expansion coefficient 20...300°C [10^{-6}/K]	16,8-18	(0-400□C)
[Ref: 233, 234, 235, 236, 237, 239, 241, 627, 628, 629, 633]		

Applications

Main applications

Lead frames, connectors, switchgear, fuse clips, contact springs, electronic industries, railway equipment, marine hardware, fittings, resistance-welding electrode holders, bearings, friction pads. The most used wrought forma are sheet, strip, rod and forgings. Literature: [Ref: 233, 234, 240, 241]

Kinds of semi-finished products/final products

Components for the electrical industry, stamped parts, connectors, relay springs.

Chemical composition

Chemical composition	Value	Comments
Cu [wt.%]	95,9-97,7	Calculated
Fe [wt.%]	0-0,2	
Mn [wt.%]	0-0,1	
Ni [wt.%]	1,6-2,5	
Pb [wt.%]	0-0,02	
Si [wt.%]	0,4-0,8	
Others [wt.%]	0,3	
[Ref: 570]		

Mechanical properties

Mechanical properties	Value	Comments
UTS [MPa]	300-780	
YS [MPa]	120-620	
Elongation [%]	10-35	
Hardness	70-240	HV
Young's modulus [GPa]	128-160	
Kirchhoff's modulus [GPa]	48-52	
Poisson ratio	0,35	Calculated
[Ref: 626, 627, 629, 631, 634]		

Materials mechanical and electrical properties in different tempers

Temper	Tensile strength, MPa	Yield strength (min), MPa	Elongation (min) A50mm, %	Hardness	Literature
H02, R420, H130	420-480	380	9	130-150 HV	[Ref: 234]
H03, R460, H140	460-530	430	7	140-160 HV	
H06, R520, H150	520-590	480	5	150-170 HV	
TM10, R600, H180	600-670	570	7	180-220 HV	
TM03, R620, H190	620-690	580	10	190-220 HV	
R460	460-580	350	16	150-190 HV	[Ref: 241, 631]
R580	580-650	470	14	170-210 HV	
R620	620-720	540	13	180-220 HV	
R680	680-780	620	10	200-240 HV	

Solution heat treated -sheet, strip	300	120	35 ($L0=5,65(S0)^{0,5}$)	70 HB, 73 HV	[Ref: 233]
Solution heat treated and cold working to typical temper-sheet, strip	440	400	12 ($L0=5,65(S0)^{0,5}$)	120 HB, 125 HV	
Precipitation hardened sheet, strip	580	520	14 ($L0=5,65(S0)^{0,5}$)	170 HB, 180 HV	
Precipitation hardened after cold working to typical temper sheet, strip	700	650	10 ($L0=5,65(S0)^{0,5}$)	190 HB, 200 HV	
Solution heat treated -rod	300	120	35 ($L0=5,65(S0)^{0,5}$)	70 HB, 73 HV	
Solution heat treated and cold working to typical temper-rod	450 550	400 520	10 ($L0=5,65(S0)^{0,5}$) 3 ($L0=5,65(S0)^{0,5}$)	125 HB, 130 HV 150 HB, 160 HV	
Precipitation hardened rod	600	540	12 ($L0=5,65(S0)^{0,5}$)	160 HB, 170 HV	
Precipitation hardened after cold working to typical temper rod	650 750	570 650	12 ($L0=5,65(S0)^{0,5}$) 10($L0=5,65(S0)^{0,5}$)	170 HB, 180 HV 200 HB, 210 HV	
Solution heat treated -wire	300	120	30 (A_{100})	-	
Solution heat treated and cold drown to typical temper-wire	550	520	-	-	
Precipitation hardened after cold drowing to typical temper wire	750	670	7 (A_{100})	-	
Solution heat treated -tube	300	120	35 ($L0=5,65(S0)^{0,5}$)	70 HB, 73 HV	
Solution heat treated and cold drown to typical temper-tube	450	380	10 ($L0=5,65(S0)^{0,5}$)	125 HB, 130 HV	
Precipitation hardened tube	550	450	15 ($L0=5,65(S0)^{0,5}$)	170 HB, 180 HV	
Precipitation hardened after cold drowing to typical temper tube	720	630	10 ($L0=5,65(S0)^{0,5}$)	200 HB, 210 HV	
Participation hardened - forgings	580	500	12 ($L0=5,65(S0)^{0,5}$)	160 HB, 170 HV	

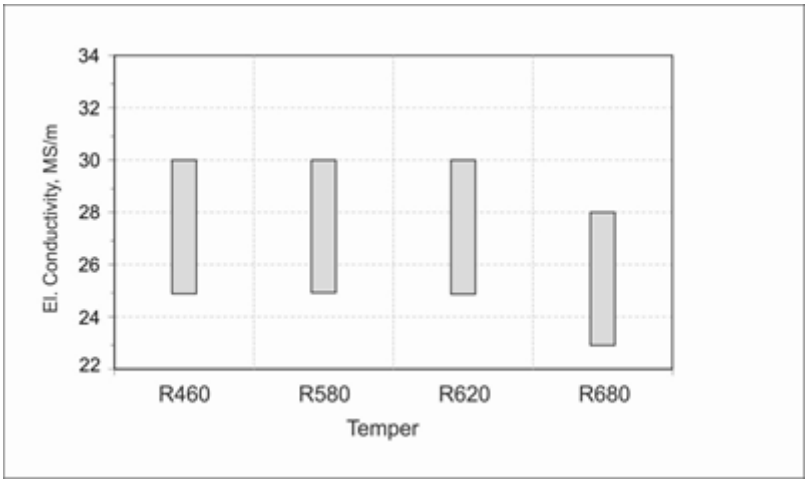
R430, Strip	430-520	330	10 (A)		EN 1654 (1997)
R450, Strip	450-600	360	3 (A)		
R510, Strip	510-600	450	10 (A)		
R600, Strip	min. 600	550	8 (A)		
R550, Wire	min. 550	430	15 ($L0=5,65(S0)^{0,5}$)		EN 12166 (2011)
R600, Wire	Min. 600	520	10 ($L0=5,65(S0)^{0,5}$)		
R640, Wire	Min. 640	590	8 ($L0=5,65(S0)^{0,5}$)		
superseturation				70,5	[Ref: 626]
superseturation+age				183,5	
superseturation+ageing (RCS)				223,7	
superseturation+ageing (RCS)+ageing				208,3	
R370	370-420	≤240	≥18 (A50)	100-140 HV	[Ref: 629]
R430	430-520	≥320	≥13 (A50)	125-160 HV	
R450	450-560	≥360	≥8 (A50)	130-180 HV	
R510	510-600	≥450	≥5	150-180 HV	
R640	≥640	≥550	≥3	≥180	
R260	min. 260	min. 60	min. 30	65-100 HV	[Ref: 630]
R460	min. 460	min. 300	min. 12	150-190 HV	
R380	min. 380	min. 260	min. 6	130-170 HV	
R600	min. 600	min. 480	min. 8	min. 190 HV	
R360 (H100)	360-430	250	>12	100-130 HV	[Ref: 631]

Mechanical properties at low temperature of CuNi2Si [Ref: 233]

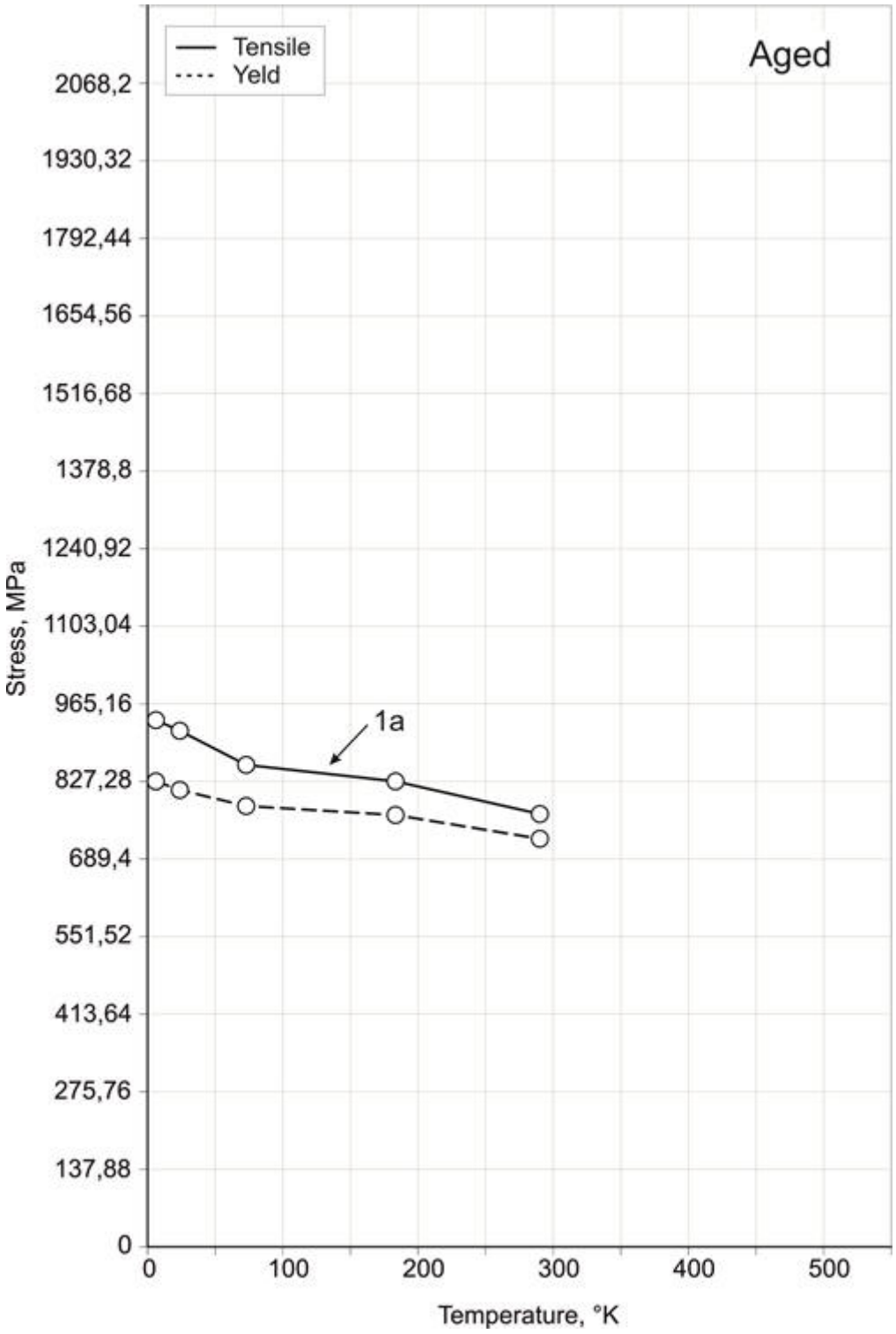
Temper	Testing temperature, °C	Tensile strength, MPa	Yield strength (min), MPa	Elongation A, %
Solution heat treated and cold worked ~35% - Rod	20	700	600	15 ($L0=4,52(S0)^{0,5}$)
	-60	720	-	18 ($L0=4,52(S0)^{0,5}$)
Precipitation hardened - Rod	22	790	738	15 ($L0=4,52(S0)^{0,5}$)
	-78	840	779	18 ($L0=4,52(S0)^{0,5}$)
	-197	870	802	24 ($L0=4,52(S0)^{0,5}$)
	-253	940	832	33 ($L0=4,52(S0)^{0,5}$)
	-269	955	842	31 ($L0=4,52(S0)^{0,5}$)
Precipitation hardened after cold working ~75%	20	800	680	9 ($L0=5,65(S0)^{0,5}$)
	-20	800	680	10 ($L0=4,52(S0)^{0,5}$)
	-70	820	690	11,5 ($L0=4,52(S0)^{0,5}$)
	-170	860	720	18,5 ($L0=4,52(S0)^{0,5}$)

Mechanical properties at elevated temperature of CuNi2Si [Ref: 233]

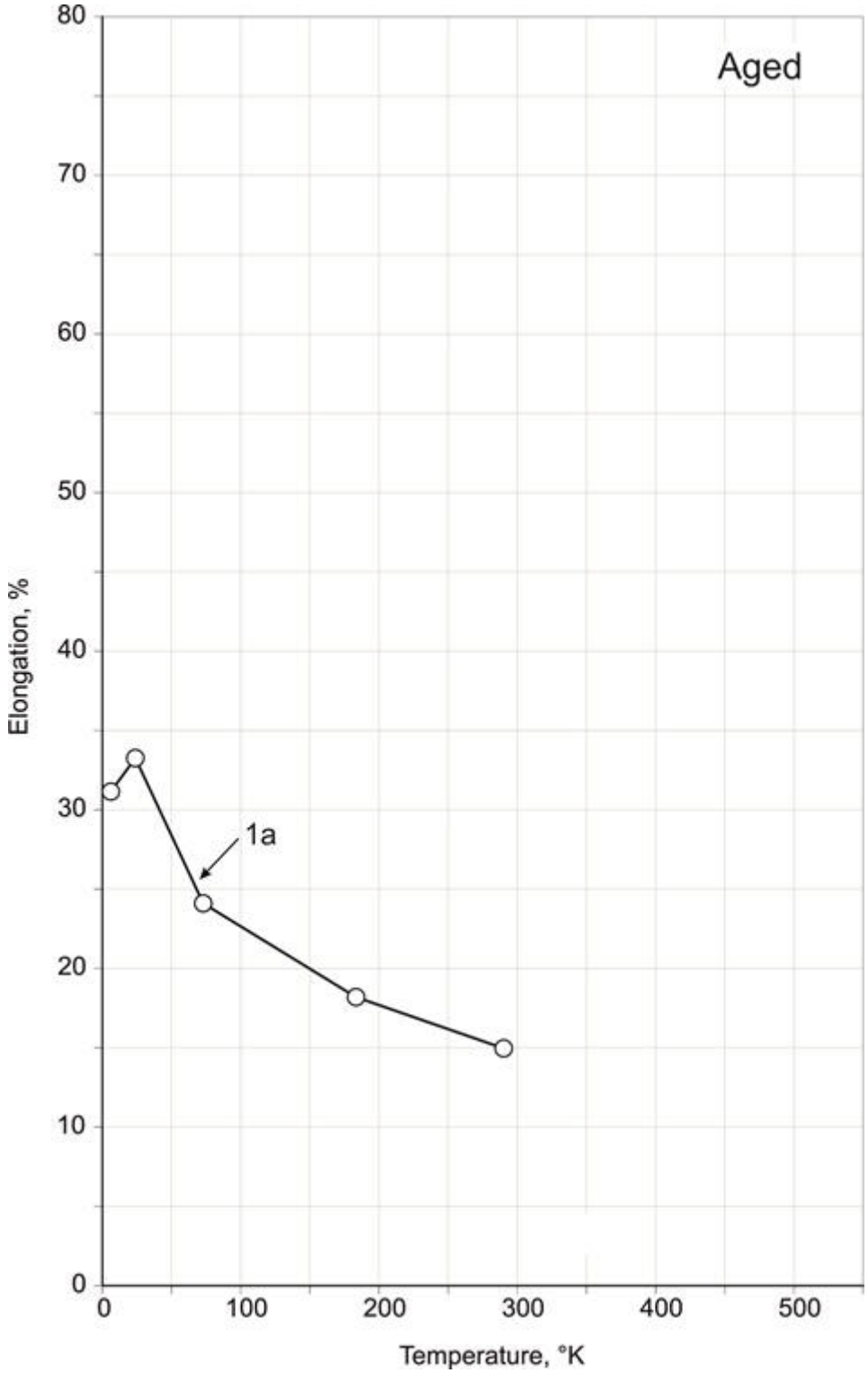
Temper	Testing temperature, °C	Tensile strength, MPa	Yield strength 0,5% ext. under load, MPa	Elongation, % on 2 in.	
Solution heat treated	20	265	-	-	
	200	250	-	-	
	300	245	-	-	
	450	190	-	-	
	600	185	-	-	
Precipitation hardened	20	605	590	-	
	200	565	550	-	
	300	500	490	-	
	450	355	345	-	
	600	240	233	-	
Precipitation hardened after cold working 75%	20	740	-	-	
	200	690	635	11,0	
	300	645	-	7,5	
	400	570	555	4,5	
	500	440	412	1,5	
	600	235	227	4,5	
	700	65	66	32,0	



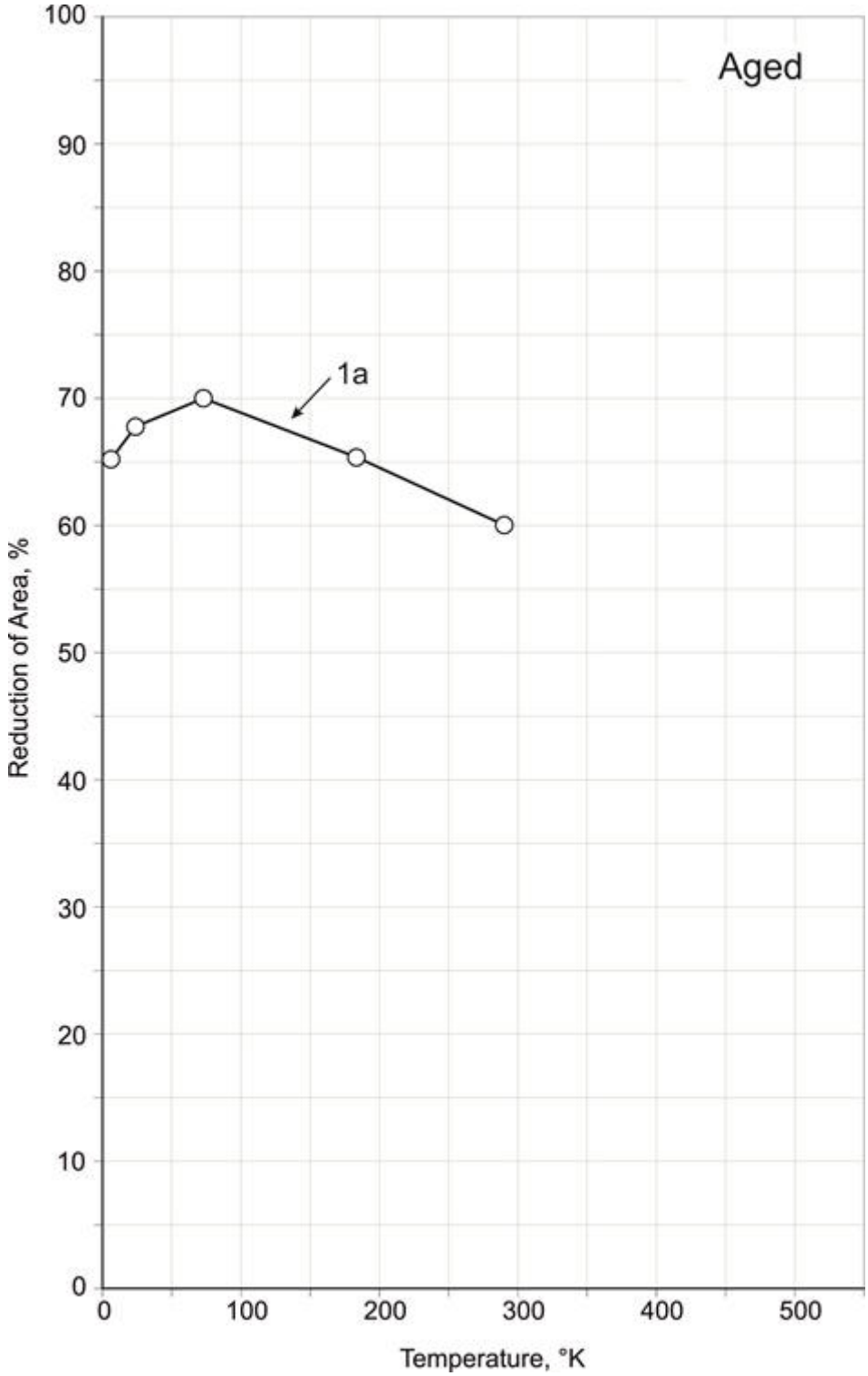
Electrical properties CuNi2Si [Ref: 241]



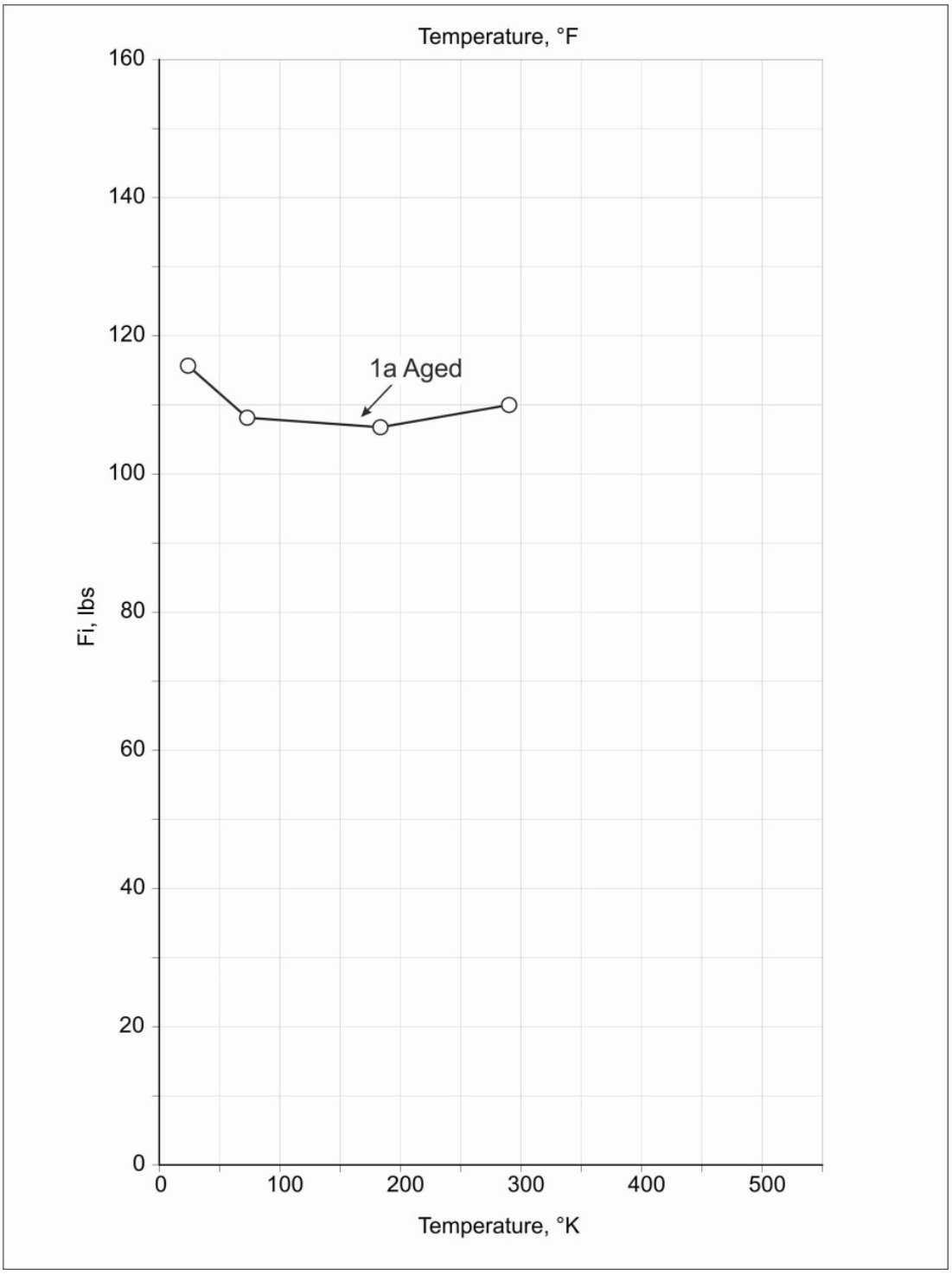
Stress vs. temperature of CuNi2Si alloy (Aged 450°C - 2 hours) [Ref: 244]



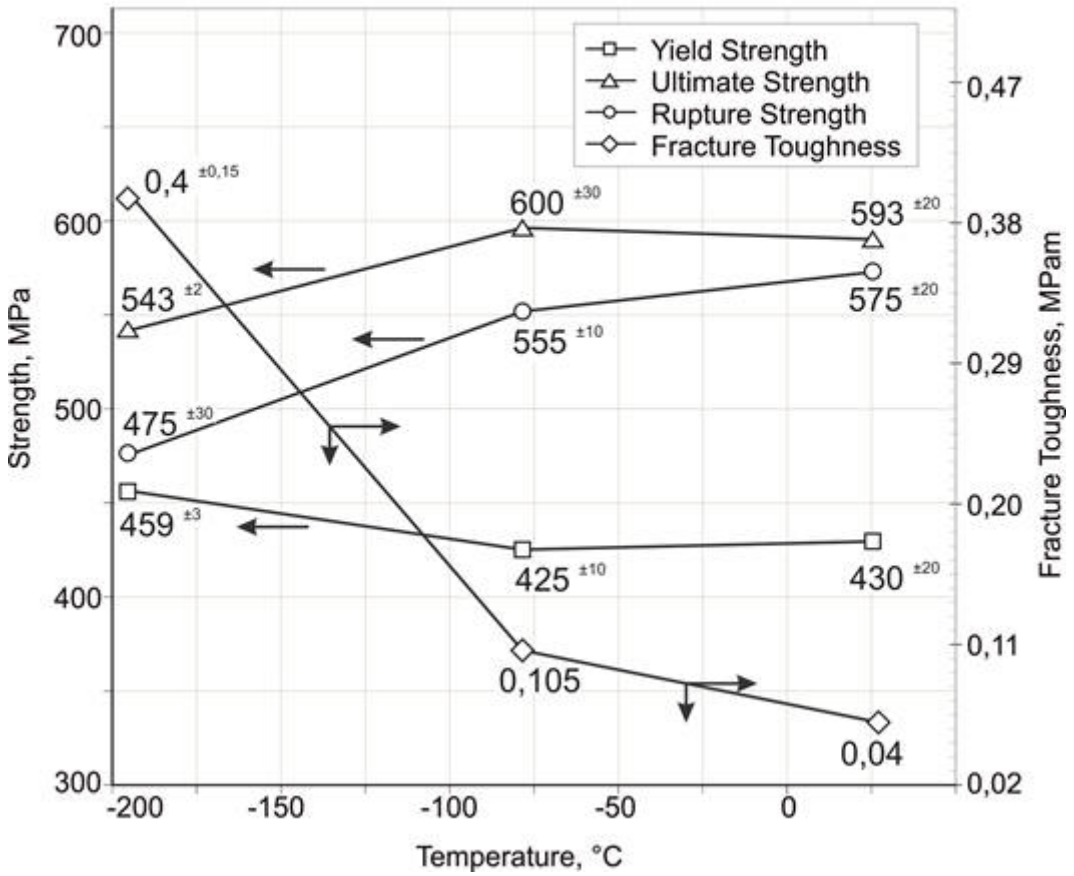
Elongation vs. temperature of CuNi2Si alloy (Aged 450°C - 2 hours) [Ref: 244]



Impact energy vs. temperature of CuNi2Si - (Aged 450°C - 2 hours) [Ref: 244]



Impact energy vs. temperature of CuNi2Si - (Aged 450°C - 2 hours) [Ref: 244]

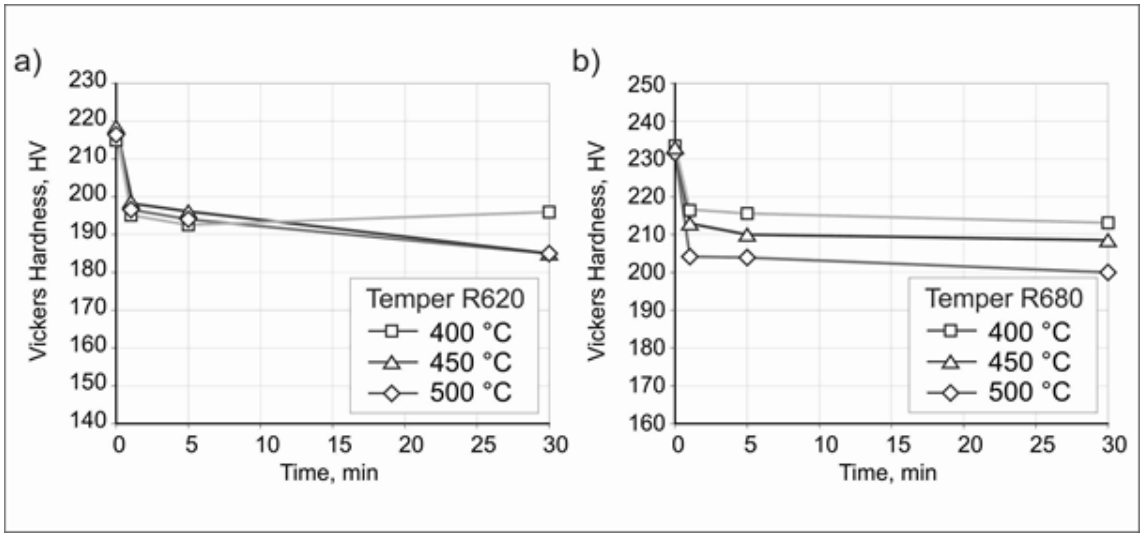


Effect of temperature on the strength and fracture toughness of precipitation hardness CuNi2Si [Ref: 237]

Exploitation properties

Heat resistance

Mechanical and electrical properties vs temperatures



Resistance to softening (Vickers hardness after heat treatment)[Ref: 241]

H Temper condition up to: 125□C- fair [Ref: 631]

TM Temper condition up to: 150□C- fair [Ref: 631]

Long-therm heat resistance, e.g. Arrhenius curve

NO DATA AVAILABLE

Half- softening temperature

NO DATA AVAILABLE

Corrosion resistance

Hydrogen embrittlement resistance

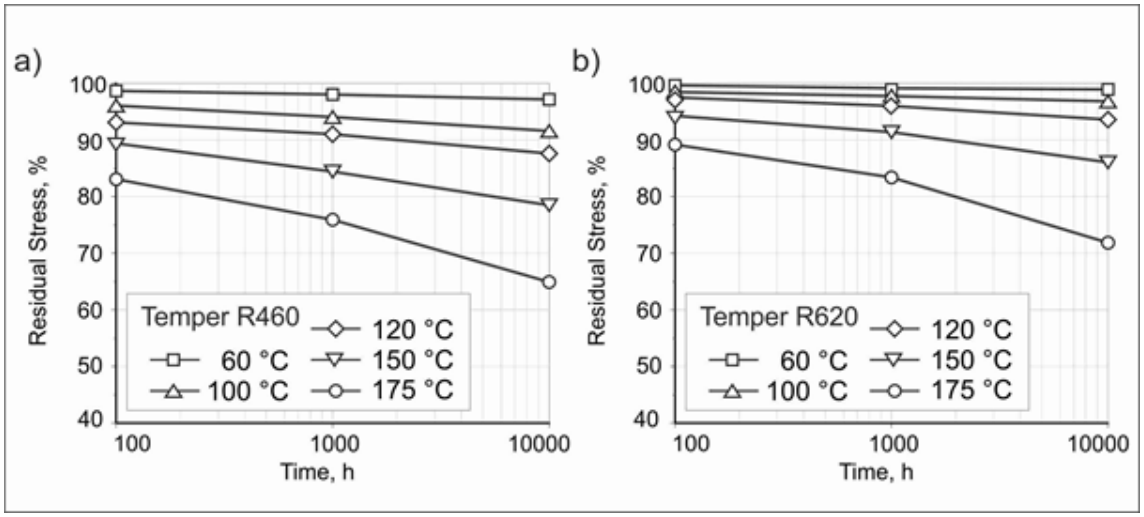
NO DATA AVAILABLE

Other kind of corrosion elements

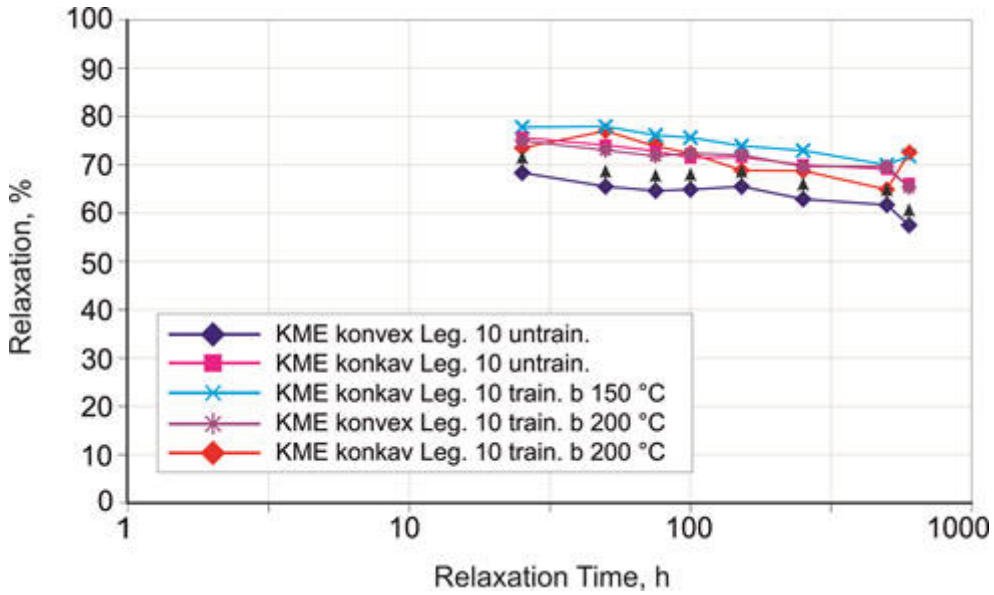
Type of corrosion	Suitability	Literature
Atmospheric	Good, Excellent	[Ref: 241, 634]
Marine environment	No data	-
Stress crack	Resistant	[Ref: 241]
Hydrogen embrittlement	No data	-
Electrolytic	No data	-
Other		-

Rheological resistance

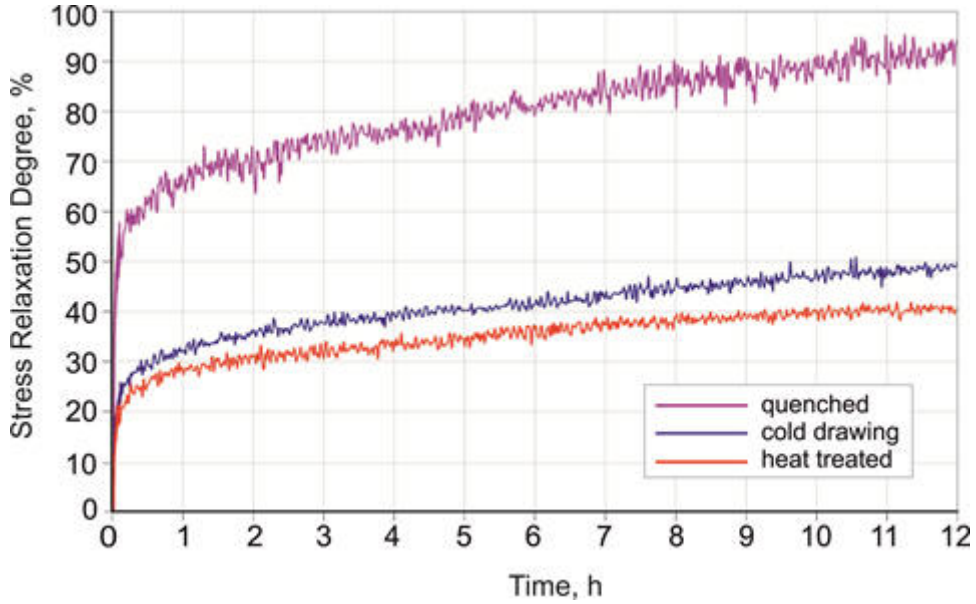
Stress relaxation



Stress relaxation CuNi2Si [Ref: 241]



Stress relaxation CuNi2Si [Ref: 238]



Stress relaxation degree for w=0,3Rm stress (1- annealed 900°C/3h and water quenched, 2- cold drown R.A. 96%, 3- age hardened 500*°C/5h* after solid solution). [Ref: 567]

Creep

Creep properties of CuNi2Si [Ref: 233]

Temper	Testing temperature, °C	Stress, MPa	Duration, h	Total extension, %	Intercept, %	Min. creep rate, %/1000h
Precipitation hardened after cold working ~88%	204	70	6000	0,16	0,018	0,0028
		141	5830	0,192	0,030	0,0029
		211	5400	0,255	0,037	0,0033
		281	5760	0,385	0,045	0,0052
		352	5760	0,50	0,072	0,0049
		422	6000	0,78	0,18	0,027

Stress for rupture of CuNi2Si [Ref: 233]

Temper	Testing temperature, °C	Stress for rupture in time indicated, MPa		
		10 h	100 h	1000 h
Solution heat treated	300	-	146	107
	450	-	67	37
Precipitation hardened	200	-	401	347
	300	-	134	104
	450	-	58	29
Precipitation hardened after cold working 88%, wire	204	584	569	548
	260	555	478	387

Precipitation hardened after cold working ~88%	300	430	402	309
	400	302	211	112
	500	134	-	-

Wear resistance

Friction resistance

NO DATA AVAILABLE

Fatigue resistance

Fatigue cracking

Fatigue strength at room temperature CuNi2Si [Ref: 233]

Temper	Number of cycles, x106	Tensile strength, MPa	Fatigue strength, MPa
Solution heat treated and cold worked 35%, rod	>10	700a	350
		700b	170
		700c	450
Precipitation hardened after cold working 37%, strip	20	690	245

a-Reversed alternating tension test

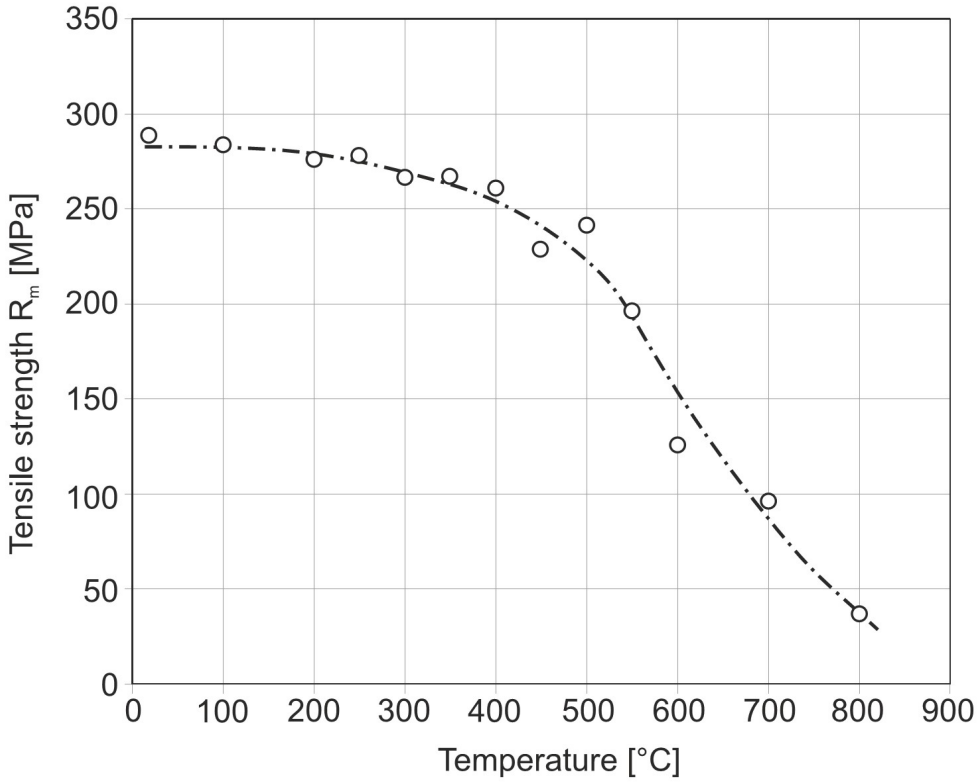
b-Torsional test

c-Pulsating test

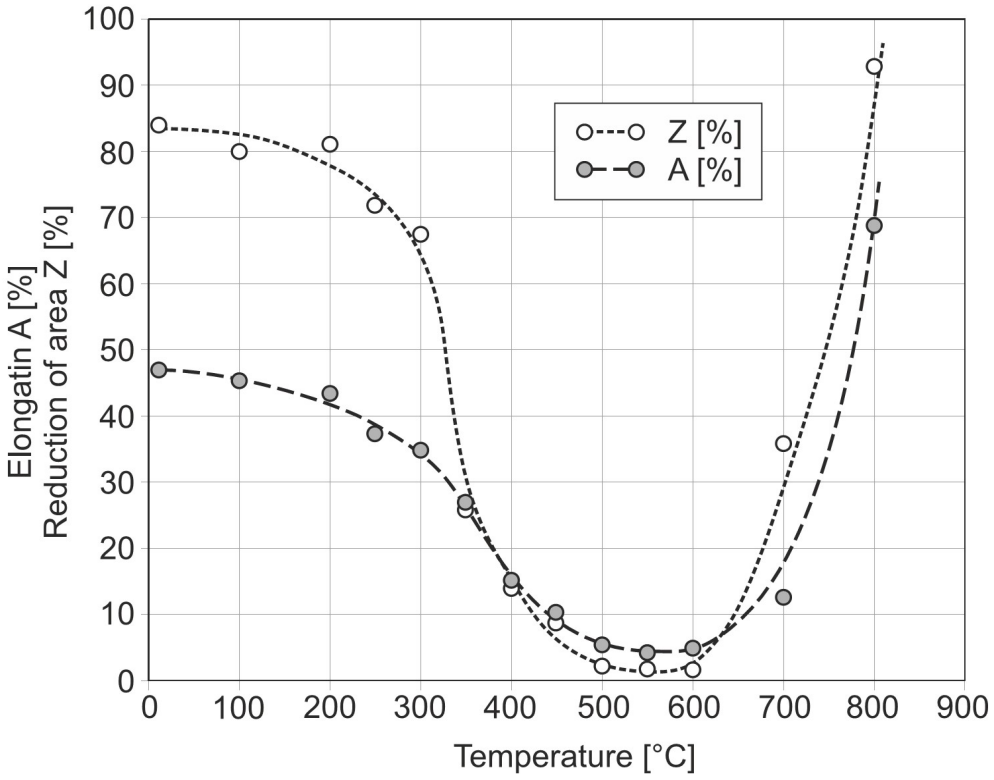
Impact strength

Impact strength at low temperature of CuNi2Si [Ref: 233]

Temper	Testing temperature, °C	Impact strength kg m/cm²
Solution heat treated and cold worked ~35% - Rod	20	>13
	-60	>15
Precipitation hardened - Rod	22	19
	-78	18,3
	-197	18,8
	-253	20,0
	-269	-
Precipitation hardened after cold working ~75%	20	13
	-20	14,5
	-70	15
	-170	15



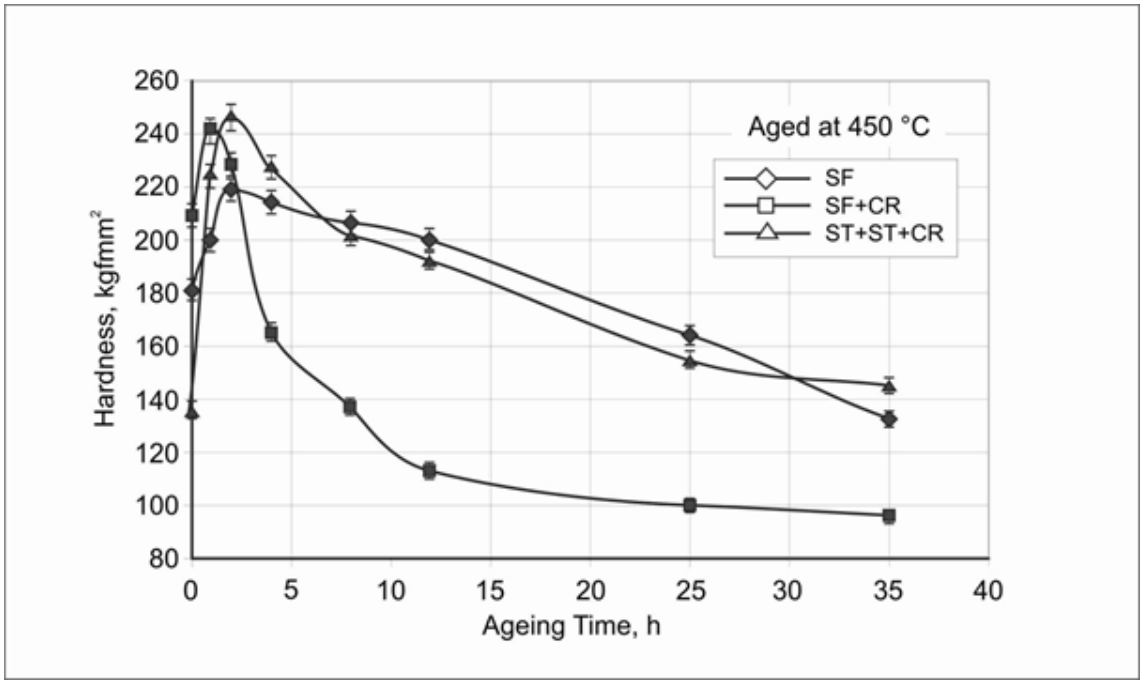
Strength vs. CuNi2Si alloy tension temperature [Ref: 633]



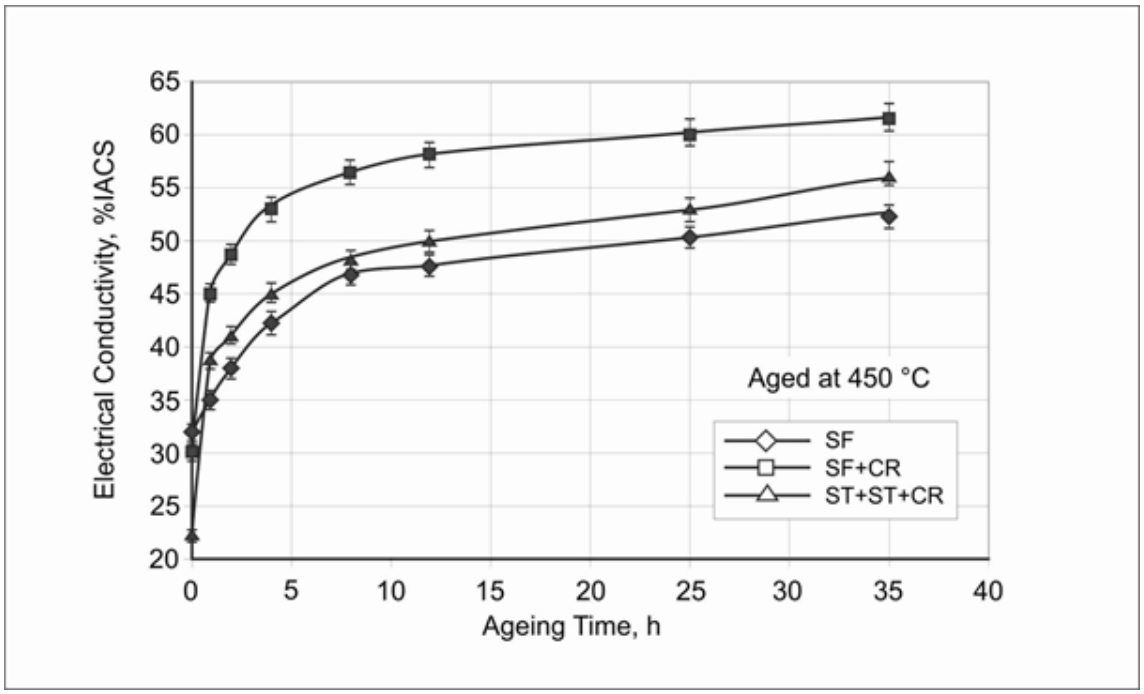
Elongation (A) and reduction of area (Z) vs. CuNi2Si alloy tension temperature [Ref: 632]

Fabrication properties

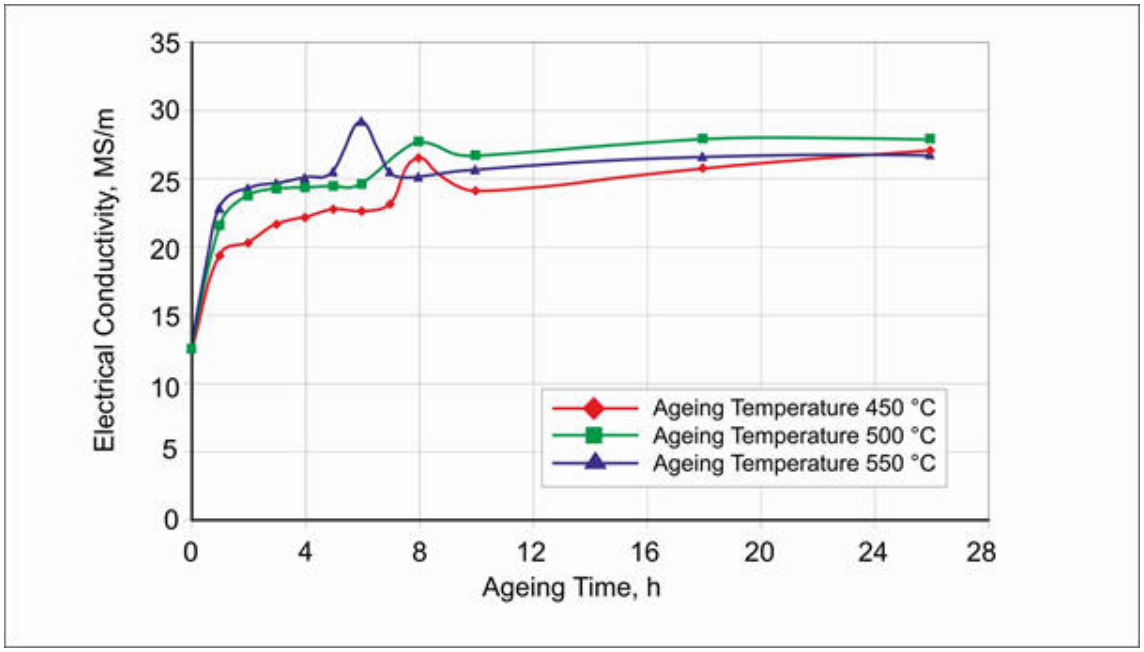
Fabrication properties	Value	Comments	Literature
Soldering	good		[Ref: 233]
Brazing	good		[Ref: 233]
Hot dip tinning	good		[Ref: 241]
Electrolytic tinning	good		[Ref: 241]
Electrolytic silvering	good		[Ref: 241]
Electrolytic nickel coating	good		[Ref: 241]
Laser welding	not recommended		[Ref: 233]
Oxyacetylene Welding	good		[Ref: 233]
Gas Shielded Arc Welding	good		[Ref: 233]
Coated Metal Arc Welding	fair		[Ref: 233]
Spot Weld	good		[Ref: 233]
Seam Weld	good		[Ref: 233]
Butt Weld	good		[Ref: 233]
Capacity for Being Cold Worked	good fair		[Ref: 233] [Ref: 233]
Capacity for Being Hot Formed	excellent		[Ref: 233]
Machinability Rating	20-30		[Ref: 233]



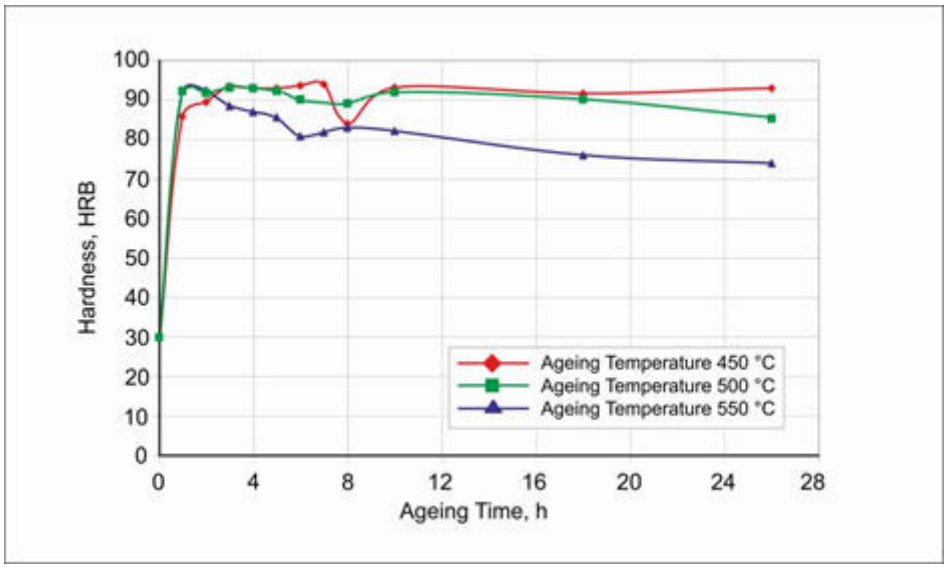
Variation of hardness with ageing time at different processing conditions-spray formed. (Note: (SF+ageing) - direct ageing of the spray formed alloy, (SF + CR + ageing) - ageing of the spray formed alloy after cold rolling to a 40% reduction in the original thickness, (SF+ST+CR+ageing) - ageing of spray formed alloy after solution treatment and cold rolling to 40% reduction in the original thickness. The solution treatment: 900℃ for 1 and water quenching. Ageing treatments: 450℃) [Ref: 231].



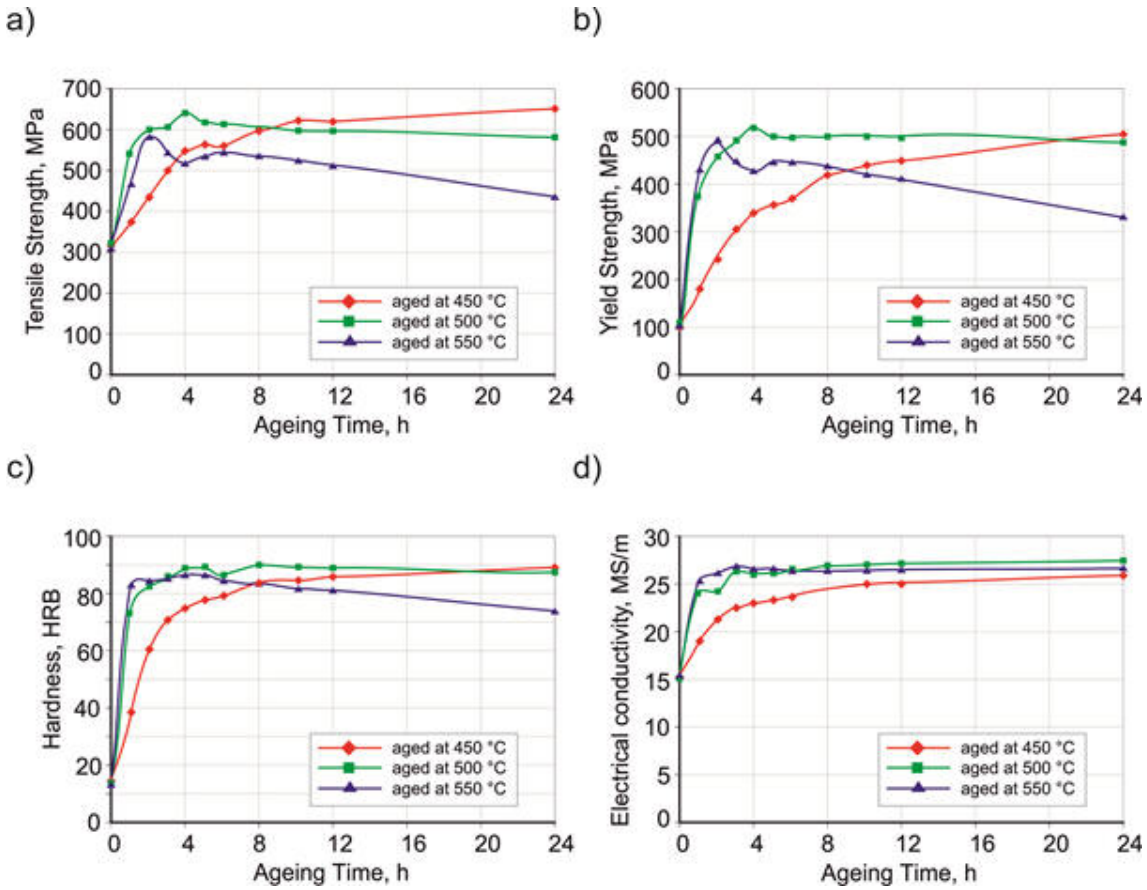
Variation of electrical conductivity with ageing time at different processing conditions-spray formed. Variation of hardness with ageing time at different processing conditions-spray formed. (Note: (SF+ageing) - direct ageing of the spray formed alloy, (SF + CR + ageing) - ageing of the spray formed alloy after cold rolling to a 40% reduction in the original thickness, (SF+ST+CR+ageing) - ageing of spray formed alloy after solution treatment and cold rolling to 40% reduction in the original thickness. The solution treatment: 900°C for 1 and water quenching.Ageing treatments: 450°C) [Ref: 231].



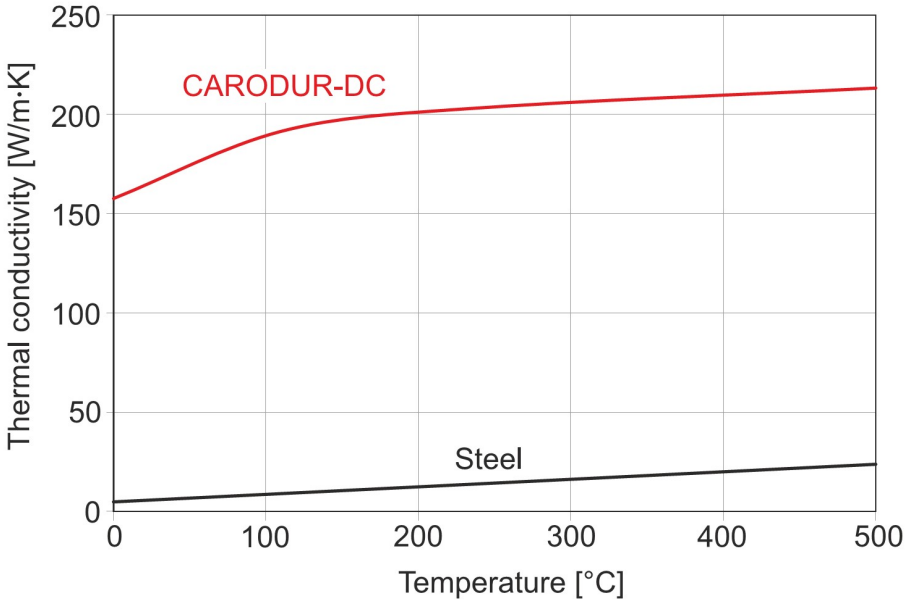
Electrical conductivity in relation to the forgings artificial ageing time, for the temperatures range 450-550°C [Ref: 567].



Hardness HRB in relation to the forgings artificial ageing time, for the temperatures range 450-550°C [Ref: 567].



Curves of artificial ageing of forgings in different temperatures after the process of forming and supersaturation from the temperature of 900°C: a)-tensile strength, b)-yield point, c)-Rockwell hardness, d)-electrical conductivity [Ref: 567].



Variation of thermal conductivity CuNi2Si with temperature [Ref: 627]

Technological properties

Technological properties	Value	Comments	Literature
Melting temperature [°C]	1040-1060		[Ref: 233, 628, 633]
Casting temperature [°C]	1130-1200		[Ref: 233]
Annealling temperature [°C]	650-725		[Ref: 233, 633, 634]
Homogenization temperature [°C]	750-850	60-15min.	[Ref: 233]
Quenching temperature [°C]	750-850		[Ref: 233, 633]
Ageing temperature [°C]	425-500	5-1h (own research)	[Ref: 233, 567]
Hot working temperature [°C]	800-900		[Ref: 233]

References:

231. **Age-hardening characteristics of Cu–2.4Ni–0.6Si alloy produced by the spray forming process** - V.C. Srivastava, A. Schneider, V. Uhlenwinkel, S.N. Ojha, K. Bauckhage, Journal of Materials Processing Technology 147 (2004)

233. **High copper alloys** - Prepared by: Conseil International Pour Le Developpment Du Cuivre (Cidec) 1204 Geneve

234. **Copper-Nickel-Silicon (CuNi2Si)** - Diehl Metall

235. **Copper-Nickel-Silicon (CuNi3Si)** - Diehl Metall

236. **Data sheet - CuNi3Si** - KME

237. **Tensile and Fracture Toughness Tests of CuNiSi at Room and Cryogenic Temperatures** - P A Ageladarakis, N P O'Dowd, G A Webster, JET–R(99)01

238. **TEM-Untersuchungen an höherfesten und elektrisch hochleitfähigen CuNi2Si-Legierungen** - Herrn Dr. Andreas Bögel gewidmet, 6/2009, 63 Jahrgang, Metall-Forschung

239. **Data sheet - CuNiSi** - Kemper

240. **Material data sheet CARODUR® A special alloy on CuNiSi-base** - Austria Buntmetall

241. **Data sheet - rolled products CuNi2Si** - Wieland-K50

244. **Low temperature mechanical properties of copper and selected copper alloys** - Richard P, Reed and Ritchie P. Mikesell, National Bureau of Standards Monograph 101

567. **AGH-UST - own research** - contact person: tknych@agh.edu.pl

570. **EN 12163 (2011) Copper and copper alloys. Rod for general purposes.** -

626. **Effect of the combined heat treatment and severe plastic deformation on teh microstructure of CuNiSi alloy** - W. Głuchowski, Z. Rdzawski, J. Sobota, J. Domagała-Dubiel, Arch. Metall. Mater., vol.61, (2016), no 2B, p.1207-1214

627. **Data sheet – CuNi2Si** - Caro-Prometa

628. **Data sheet – Colsibro CuNi2Si** - Columbia Metals

629. **Data sheet –CuNi2Si** - Amari Copper Alloys Ltd

630. **Data sheet – CuNi2Si** - SEEBERGER

631. **Data sheet –High-Performance Alloys SB22** - Diehl Metall

632. **Analysis of cracking of low-alloy copper stretched at elevated temperature** - W. Ozgowicz, E. Kalinowska-Ozgowicz, K. Lenik, A. Duda, Frattura ed Integrità Strutturale, 35 (2016) 434-440; DOI: 10.3221/IGF-ESIS.35.49

633. **Data sheet –CuNi2Si** - OTTO FUCHS DULKEN GmbH

634. **Data sheet –CuNi2Si Metelec** - VULCAN INDUSTRIAL ESTATE LEAMORE LANE

WALSALL