CuFe2P

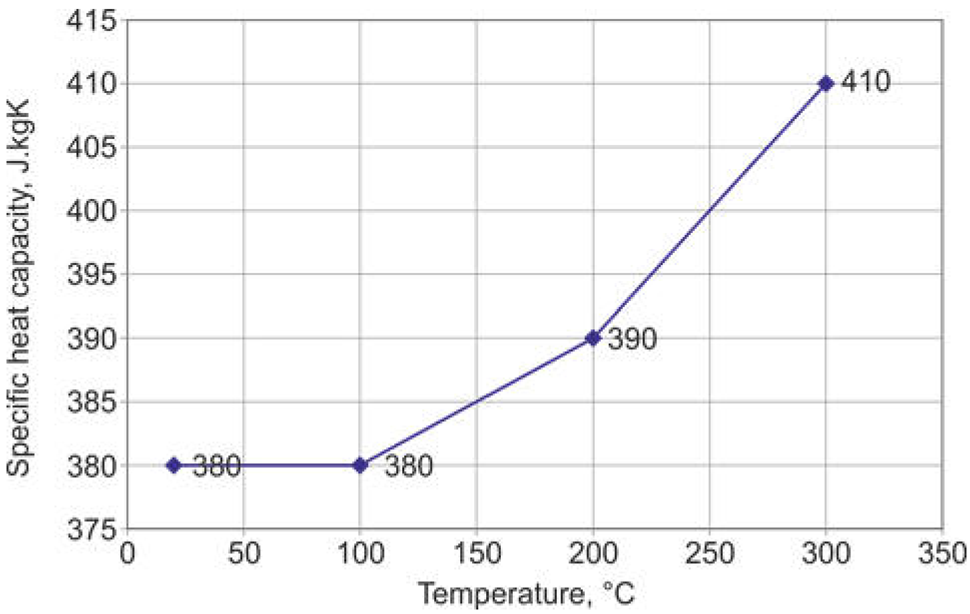
UNS:C19400
EN:CW107C

Manufactures list:
Aurubis (http://www.aurubis.com/en/) - PNA 212
KM Europa Metal AG (http://www.kme.com/) - STOL194, STOL79
Luvata (http://www.luvata.com/) - CuFe2P
Nexans (http://www.nexans.us/) - CuFe2P

High strength modified copper alloy, best combinations of electrical conductivity, mechanical strength, forming properties and stress relaxation resistance.
CuFe2p fits applications requiring excellent hot and cold workability as well as high strength and conductivity. Alloy CuFe2P can be used when copper C1100 and others lack sufficient strength. Furthermore, CuFe2P resistance to softening allows it to retain strength after extended periods at elevated temperatures. CuFe2P can be selected to replece the brass alloys when improved solderability is required.

Basic properties

Basic properties	Value	Comments
Density [g/cm^3]	8,78-8,94	
Specific heat capacity [J/(kg*K)]	380	
Temperature coefficient of electrical resistance (0...100°C) [10^{-3}/K]	3,3	20-300°C
Electrical conductivity [T=20°C, (% IACS)]	60	
Thermal conductivity [W/(m*K)]	260	
Thermal expansion coefficient 20...300°C [10^{-6}/K]	17,6	
[Ref: 269, 270, 272, 255, 256, 275, 277]		



Heat capacity of CuFePZn (Fe:2,4, Zn:0,12, P:0,03%) vs temperature [Ref: 288]

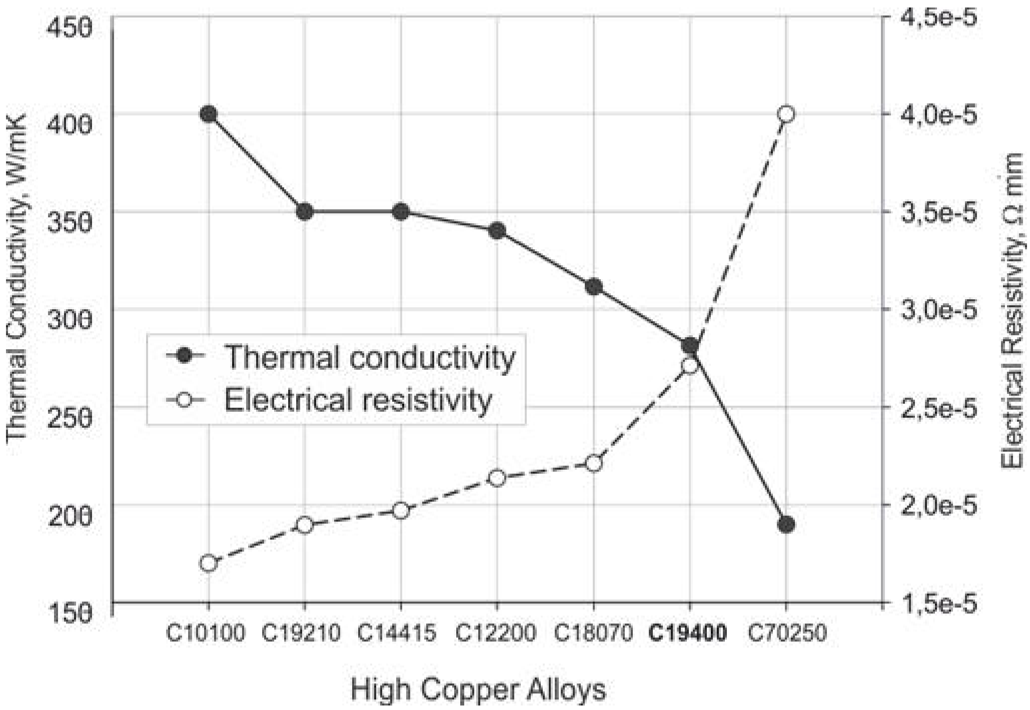
Electrical conductivity requirements according standard ASTM B465

Temper	Electrical conductivty, MS/m	Electrical conductivity, % IACS	Literature

O50	37,7-43,5	65-75	[Ref: 250]
O60	37,7-43,5	65-75	
O61	37,7-43,5	65-75	
O62	37,7-43,5	65-75	
H01	Min 35	min.60	
H02	Min 35	min.60	
H03	Min 35	min.60	
H04	Min 35	min.60	
HO6	Min 35	min.60	
HO8	Min 35	min.60	
H10	Min 35	min.60	
H14	Min 35	min.60	

Electrical conductivity requirements of C19400 for lead frames

Name of alloy	Electrical conductivty, MS/m	Electrical conductivity, % IACS	Source
Lead frame alloy	Min38	Min 60	[Ref: 252]



Thermal conductivity and electrical conductivity for CuFe2P (C19400) and different copper alloys [Ref: 260]

Applications

Main applications

Circuit breaker components, contact springs, electrical clamps, springs, terminal, flexible hose, fuse clips, gaskets, gift hollowware, plug contacts, rivets, nit, welded condenser tubes, semiconductor lead frames, cable shielding. *Literature:* [Ref: 268, 270, 271, 272, 254, 274, 278, 286]

Kinds of semi-finished products/final products

Product	Specification
Bar, Rolled	ASTM B465
Plate	ASTM B465
Sheet	ASTM B465, B694
Strip	ASTM B465, B888, B694
Tube, Welded	ASME SB543

Chemical composition

Chemical composition	Value	Comments
Cu [wt.%]	97,02-97,835	Calculated
Fe [wt.%]	2,1-2,6	
P [wt.%]	0,015-0,15	
Pb [wt.%]	0-0,03	
Zn [wt.%]	0,05-0,20	
[Ref: 268]		

Chemical composition of CW107C according ASTM [Ref: 269]

Chemical composition of CW107C according MATWEB [Ref: 270]

Chemical composition of CW107C according Wieland [Ref: 271]

Chemical composition of CW107C according KME [Ref: 272]

Chemical composition, wt.%												
Ag	**Mg**	**Sn**	**Ni**	**Si**	**Cr**	**Zr**	**Fe**	**P**	**Pb**	**Zn**	**other**	**Cu**
-	-	-	-	-	-	-	2.1-2.6	0.015-0.15	max. 0.03	0.05-0.20	-	min. 97.7

Chemical composition, wt.%												
Ag	**Mg**	**Sn**	**Ni**	**Si**	**Cr**	**Zr**	**Fe**	**P**	**Pb**	**Zn**	**other**	**Cu**
-	-	max 0.03	-	-	-	-	2.1-2.6	0.015-0.15	max. 0.03	0.05-0.20	max 0.15	min. 97.0

Chemical composition, wt.%												
Ag	Mg	Sn	Ni	Si	Cr	Zr	Fe	P	Pb	Zn	other	Cu
-	-	-	-	-	-		2.4	0.03	-	0.12	Max 0.2	min. 97.0

Chemical composition, wt.%												
Ag	**Mg**	**Sn**	**Ni**	**Si**	**Cr**	**Zr**	**Fe**	**P**	**Pb**	**Zn**	**other**	**Cu**
-	Max0.1	-	-	-	-	-	2.1-2.6	0.015-0.15	-	0.05-0.20	Max 0.2	min. 97.0

Mechanical properties

Mechanical properties	Value	Comments	Literature
UTS [MPa]	275-570		
YS [MPa]	110-480		
Elongation [%]	2-30		
Hardness	80-170		
Young's modulus [GPa]	115		
Kirchhoff's modulus [GPa]	44		
Poisson ratio	0,33		

Mechanical requirements according ASTM standards (different tempers)

Temper	Tensile strength, MPa	Yield strength 0,2%, MPa	Elongation A $_{50}$, %	Literature
O61	275-435	110	10	[Ref: 250]
H02	365-435	250	6	
H04	415-485	365	3	
H06	460-505	440	2	
H08	485-525	460	2	
H10	505-550	485	1	

Mechanical properties of flat products, 0,64 mm thick

Temper	Tensile strength, MPa	Yield strength, 0,2%, MPa	Elongation A $_{50}$ mm, %	Literature
O60	310	Max 150	Min 29	[Ref: 250]
O50	345	160	6	
HO4	440	435	4	
HO8	490	480	2	

Mechanical properties according DIN EN 12449 (R300 wall thikckness - 10 mm, R70, R420 - wall thickness 5mm)

Temper	Tensile strength, MPa	Yield strength, 0,2%, MPa	Elongation A_{50} mm, %
R300	310	Max 150	Min 29
R370	370	250	15
R420	440	320	5

Hardness of CW107C according DIN EN 12449 (wall thikckness - 10 mm)

Temper	Hardness, HV		Hardness, HB	
	min	max	min	max
H085	85	115	80	110
H110	110	140	105	135

H135	135	-	130	-

Mechanical properties of CW107C flat products Wieland

Temper	Tensile strength, MPa	Yield strength, MPa	Elongation, %	Electrical conductivty, MS/m		Literature
				min	max	
R300	300-340	max.240	min.20	35	41	[Ref: 271]
R340	340-390	min 240	min.10	35	41	
R370	370-430	min.330	min.6	35	41	
R420	420-480	min.380	min.3	35	41	
R470	470-530	min.440	min.4	35	41	
R530	530-570	min.470	min.5	35	41	

Hardness vs temper of CW107C

Temper	HV	Literature
H08	80-100	[Ref: 271]
H10	100-120	
H12	120-140	
H13	130-150	
H14	140-160	
H15	150-170	

Mechanical properties of CuFe1P according to SofiaMed

Temper	Tensile strength MPa	Yield strength MPa	Hardness Vickers HV	Elongation A10 %	Literature
H02/R370/HV110	370-430	330	110-140	>8	[Ref: 648]
H04/R415/HV125	415-480	380	125-145	>4	
H08/R480/HH140	480-525	440	140-160	>3	
H10/R530/HV150	530-570	470	150-170	>3	

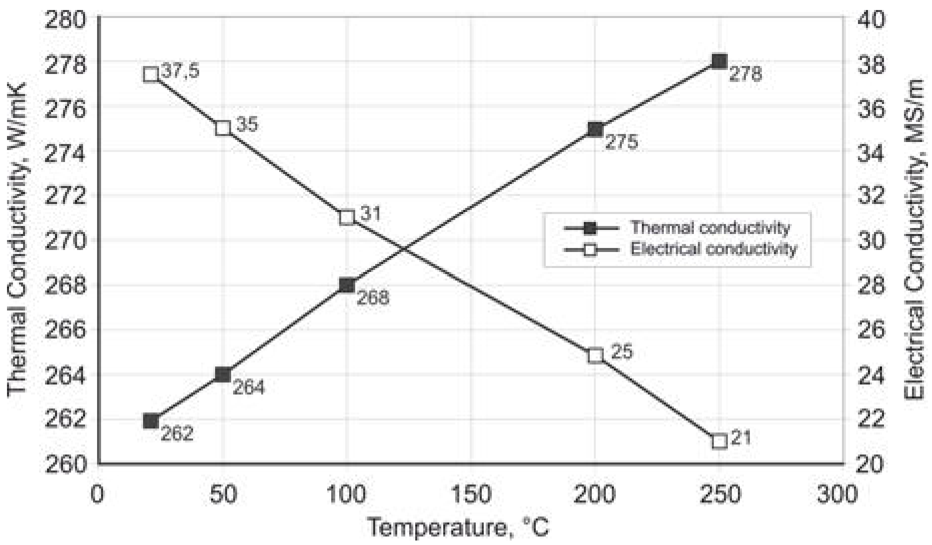
Exploitation properties

Heat resistance

Mechanical and electrical properties vs temperatures

Electrical conductivity and thermal conductivity of 19400 strip in elevated temperature (annealed temper O60) [Ref: 254, 257]

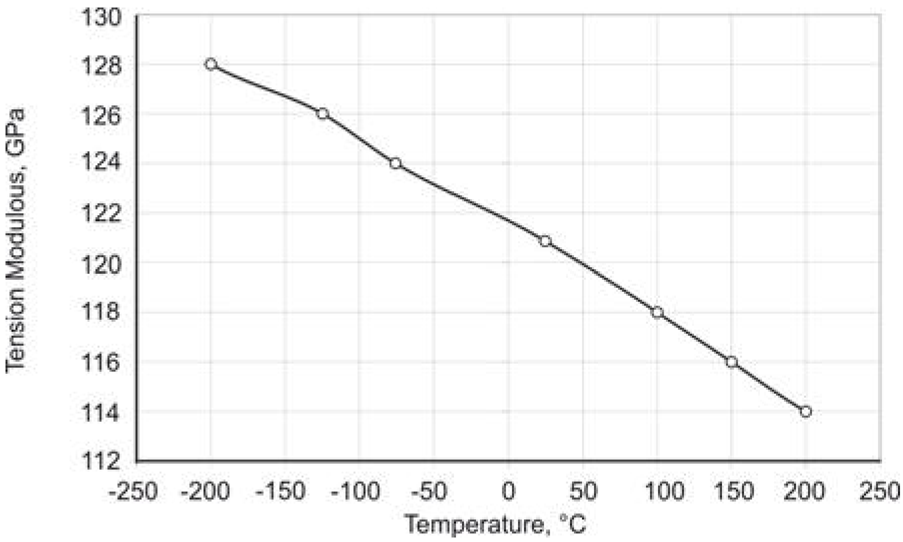
Temperature, ?C	Thermal conductivity, W/mK	Electrical conductivity/ MS/m
20	262	37,5
50	264	35
100	268	31
200	275	25
250	278	21



Electrical conductivity and thermal conductivity vs annealing temperature according data in table

Elastic modulus vs temperature of CW107C [Ref: 91]

Temperture, ºC	Modulus E, GPa	Literature
-200	128	[Ref: 91]
-125	126	
-75	124	
25	121	
100	118	
150	116	
200	114	

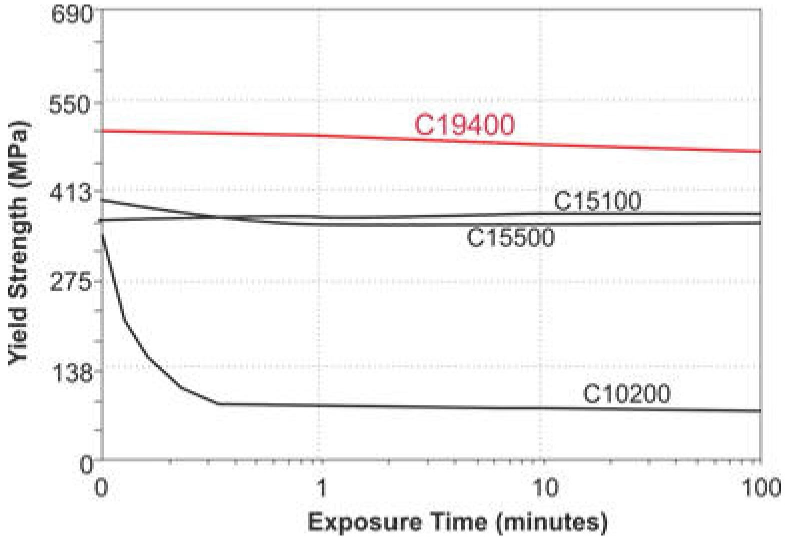


Elastic modulus vs elevated temperature [Ref: 91]

Typical room-temperature and low-temperature (cryogenic) properties of C19400 [Ref: 254, 257]

Temperature, ?C	Tensile strength, MPa	Yield strength, MPa	Elongation, 50, %
20	325	170	28
20	405	360	15
20	455	405	10
-196	475	195	38
-196	570	425	30
-196	615	485	23

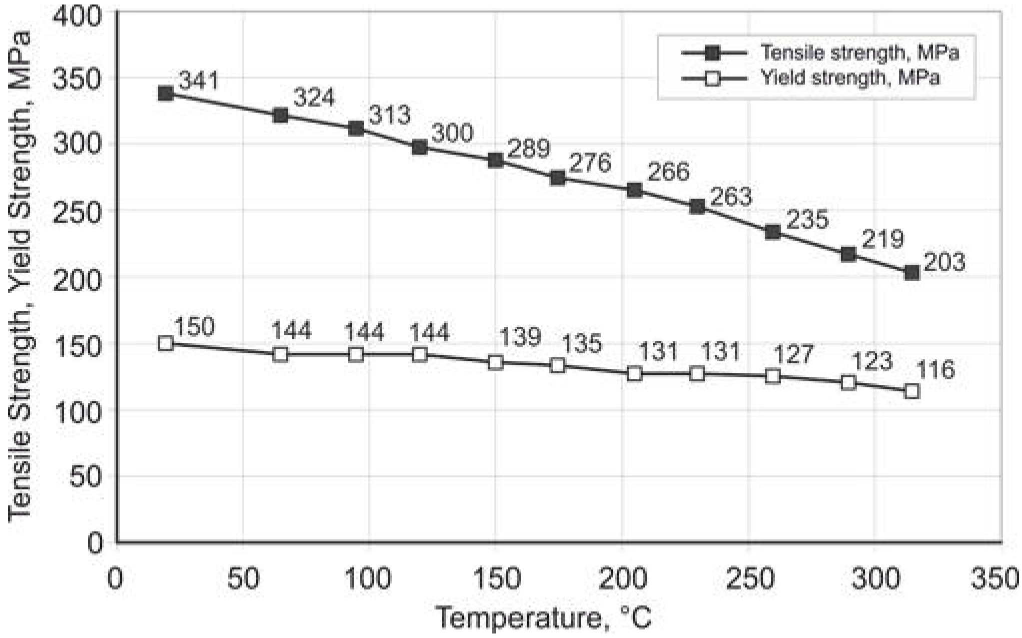
Softening Resistance: Leadframes are a perfect example of the type of processing that can cause parts to soften and subsequently fail. During packaging, they may be subjected to temperatures as high as 350°C for several minutes. Below figure shows the softening behavior of CW107C (C19400) and some other copper leadframe materials at 350°C. The resistance to softening exhibited by C19400 enables it to maintain the strength required to resist deformation in handling and automated assembly of the device onto a printed circuit board.



Softening behavior of CuFe2P and various lead frame copper alloys at 350°C [Ref: 278]

Typical elevated temperature properties of annealed C19400 strip [Ref: 254, 257]

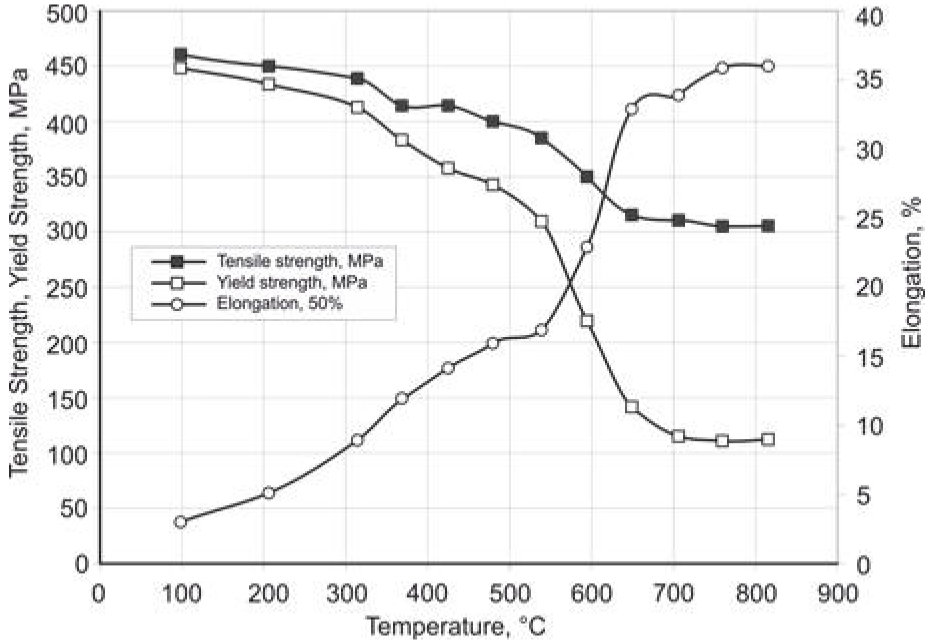
Temperature, °C	Tensile strength, MPa	Yield strength, MPa	Literature
20	341	150	[Ref: 254, 257]
65	324	144	
95	313	144	
120	300	144	
150	289	139	
175	276	135	
205	266	131	
230	253	131	
260	235	127	
290	219	123	
315	203	116	



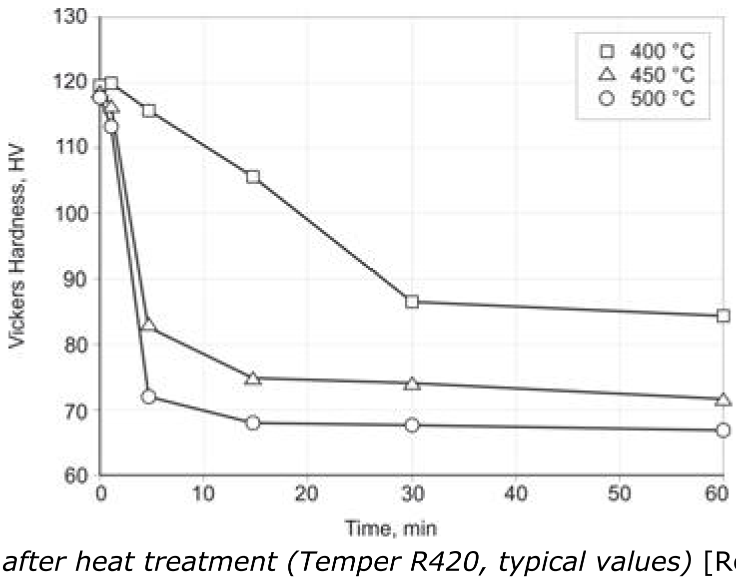
Tensile strength, yield strength vs annealing temperature according data in table [Ref: 254, 257]

Typical response of C19400 strip [Ref: 254, 257]

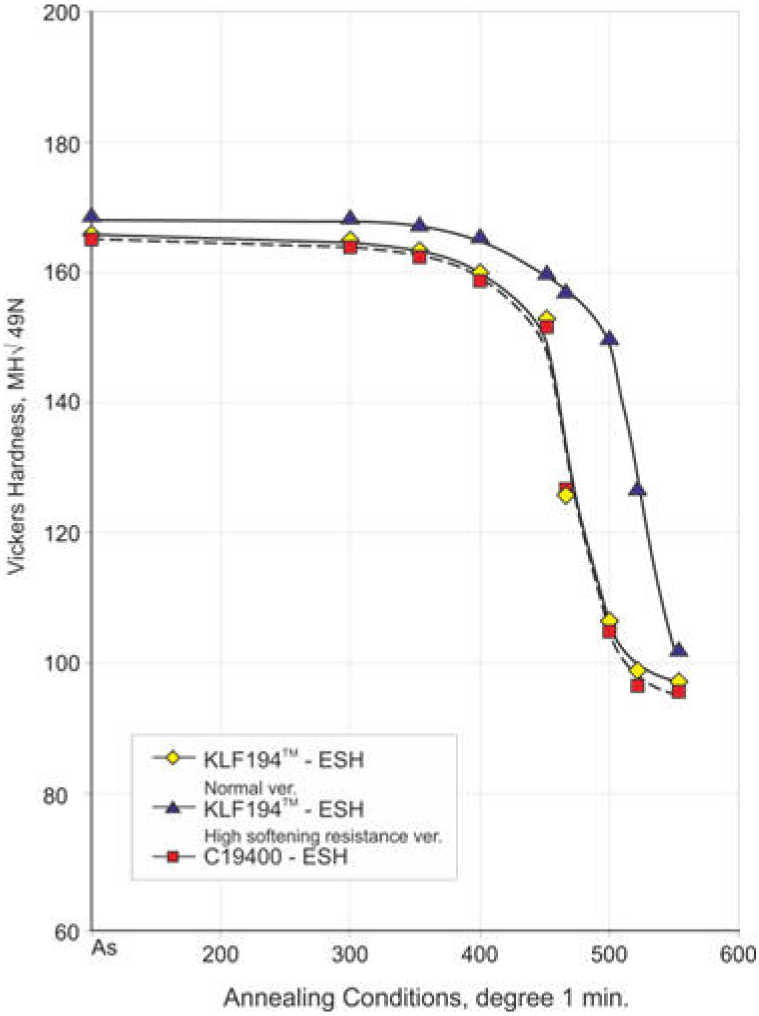
Temperature, °C	Tensile strength, MPa	Yield strength, MPa	Elongation, 50, %	Literature
100	460	450	3	[Ref: 254, 257]
205	450	435	5	
315	440	415	9	
370	415	385	12	
425	415	360	14	
480	400	345	16	
540	385	310	17	
595	350	220	23	
650	315	140	33	
705	310	115	34	
760	305	110	36	
815	305	110	36	



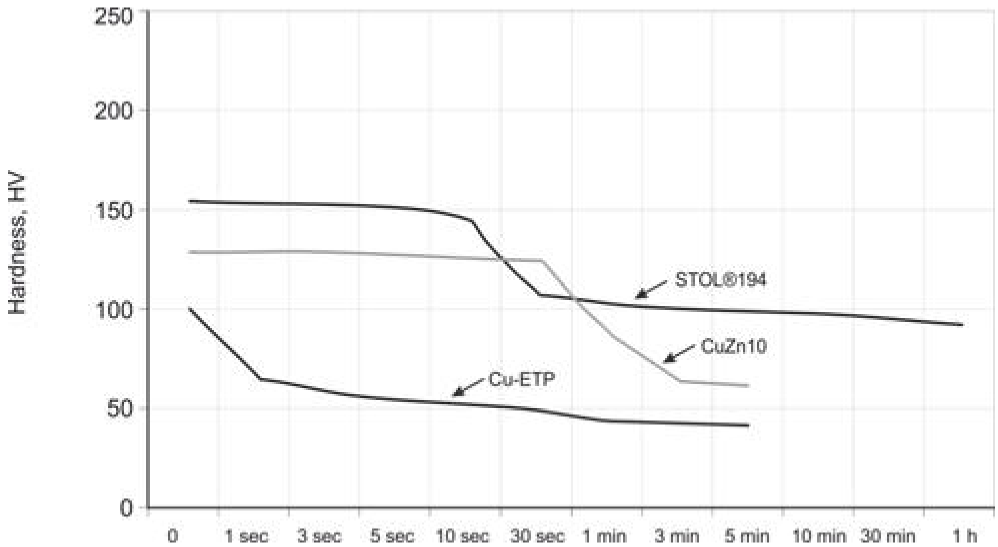
Tensile strength, yield strength and elongation vs annealing temperature according data in table [Ref: 254, 257]



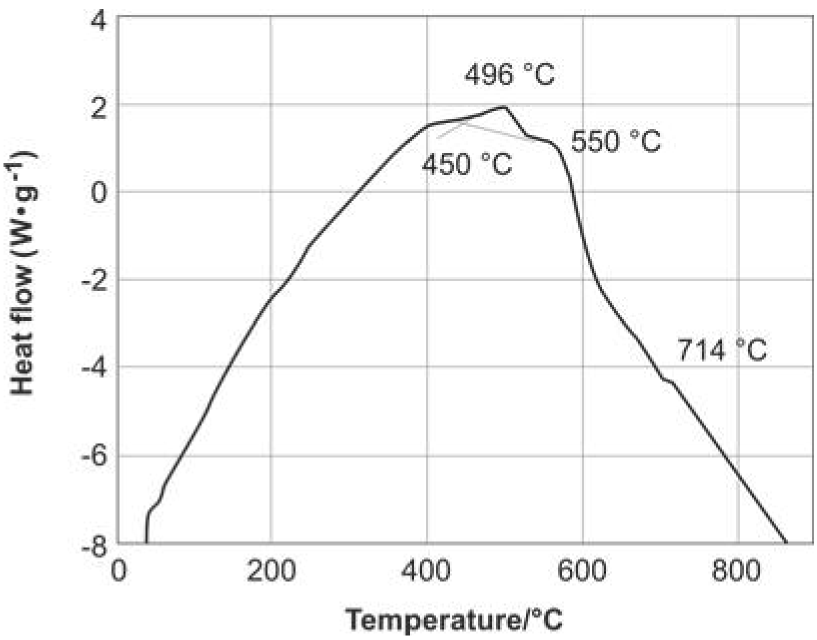
Vickers hardness after heat treatment (Temper R420, typical values) [Ref: 575]



Softening curve of CuFe2P according Kobe



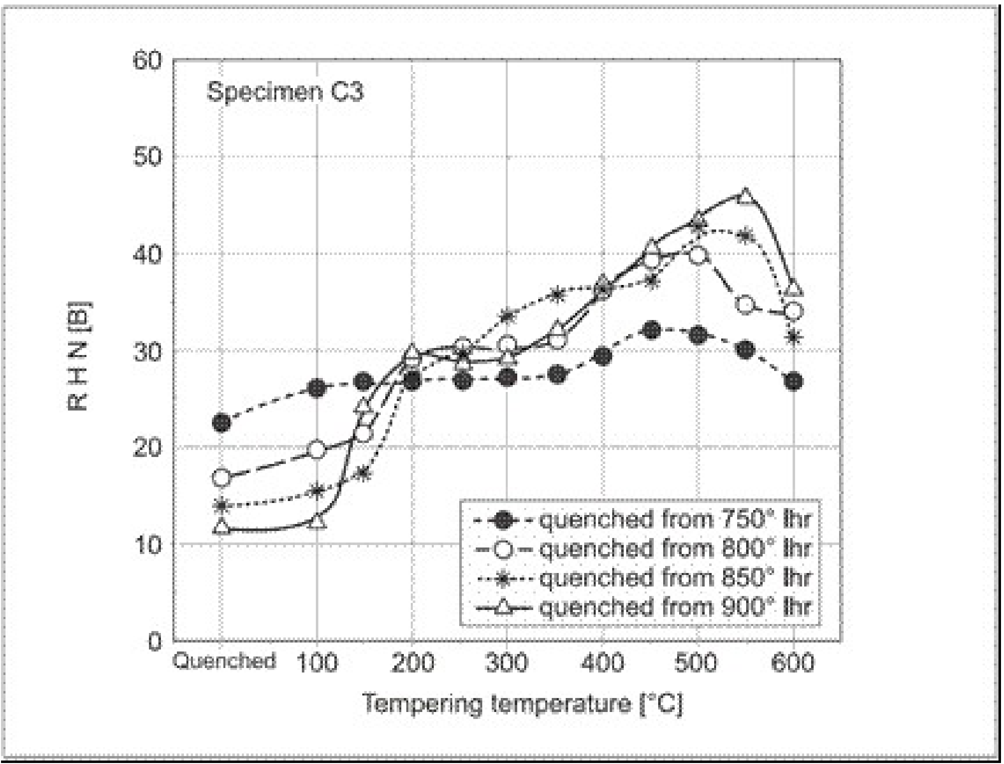
Softening characteristic at 500 °C (hard soldering, laser, resistance welding of cuFe2P, CuETP and CuZn10 [Ref: 290]



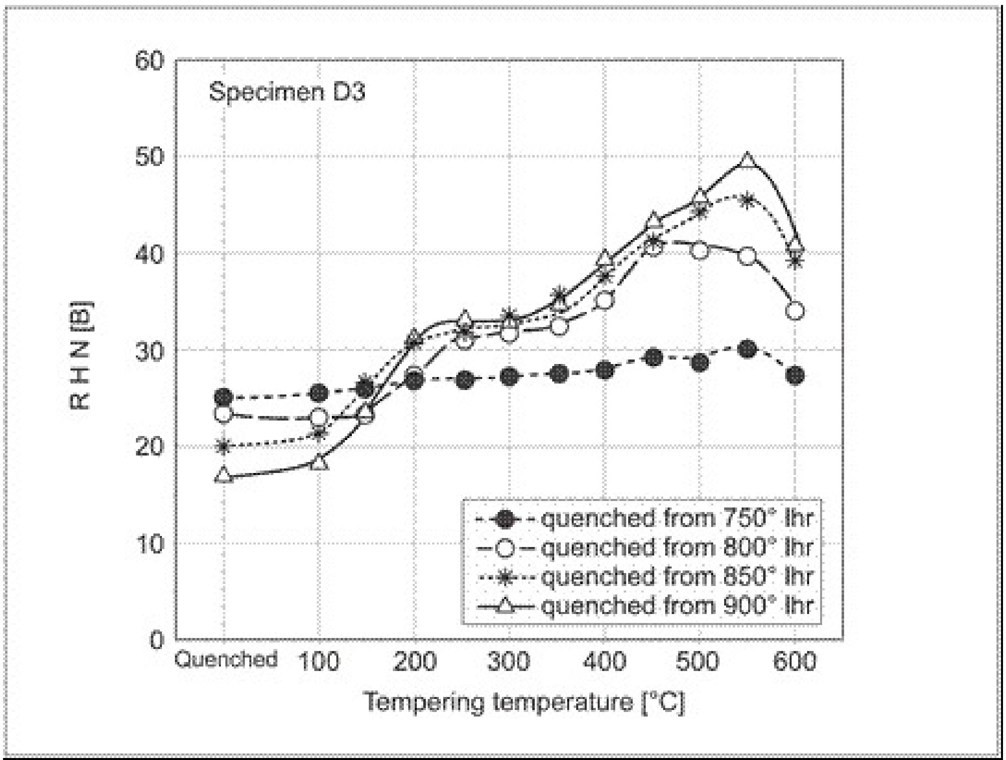
DSC curves of CuFe2P (C19400) alloy with heating rate of 10 °C/min [Ref: 291]

Specimens chemical composition (see following graphs for mechanical/electrical vs temperature properties [Ref: 649]

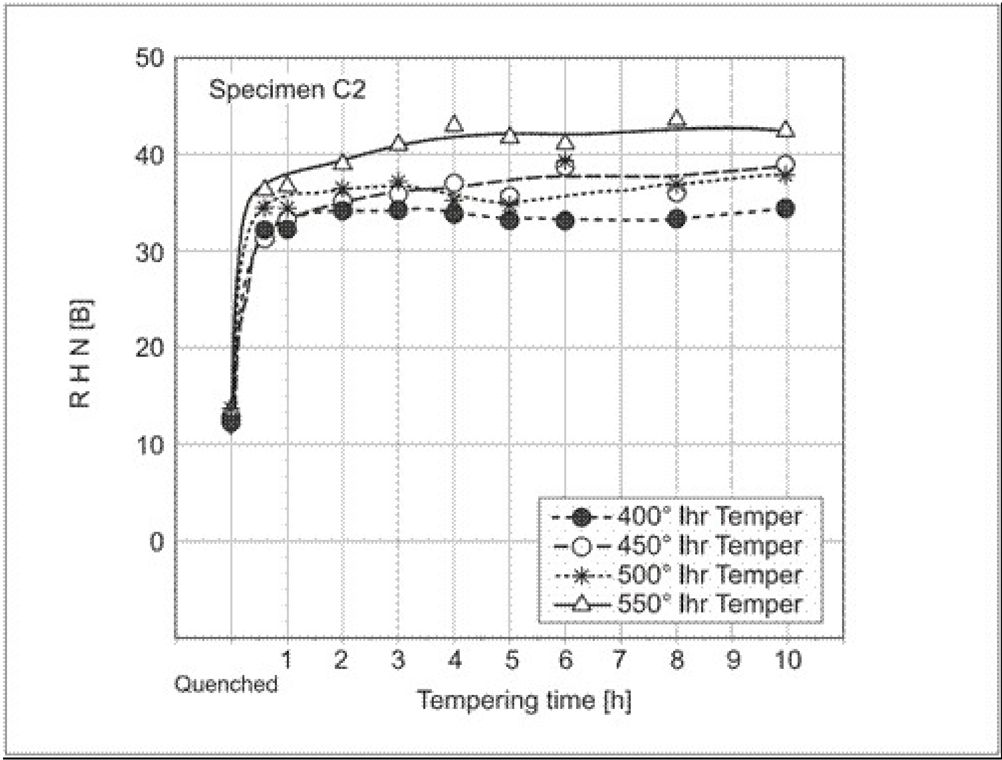
Specimens No	**Fe**	**P**	**Fe+P**
	% wt.		
C1	0	0,00	0,00
C2	2,48	0,43	2,91
C3	2,38	0,67	3,05
C4	1,96	0,95	2,91
C5	1,52	1,44	2,96
C6	0,97	1,96	2,93
D1	3,94	0,00	3,94
D2	3,39	0,64	4,03
D3	3,18	0,90	4,08
D4	2,53	1,46	3,99
D5	1,94	2,04	3,98



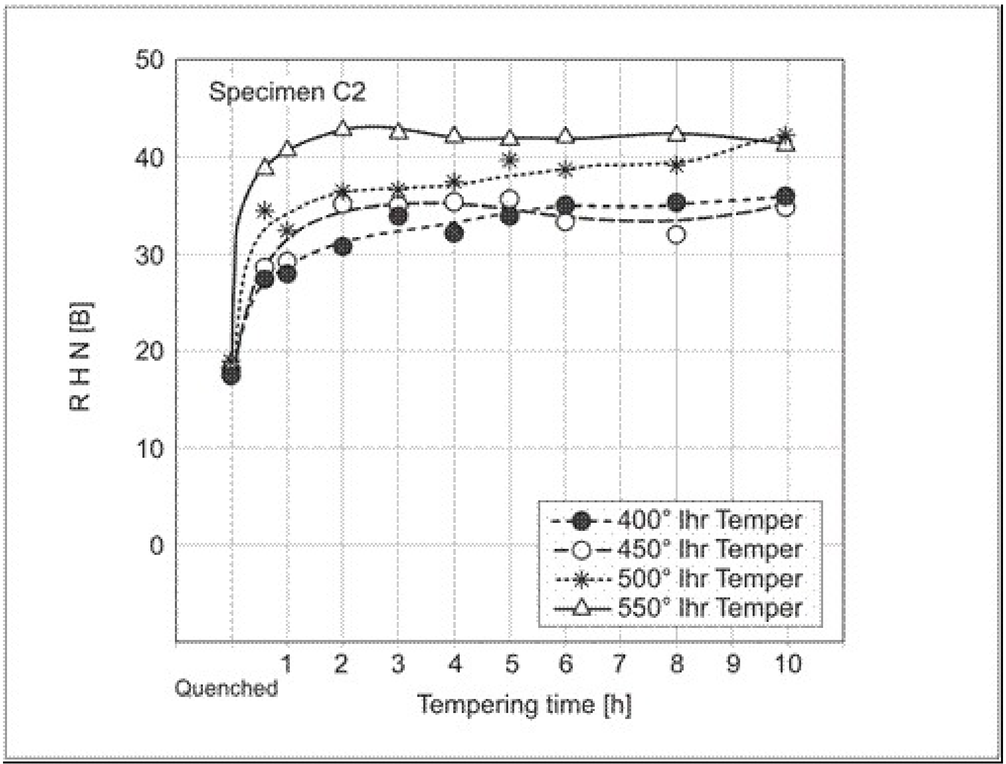
Age-hardening of several Cu-F2P alloys (specimen C3) [Ref: 649]



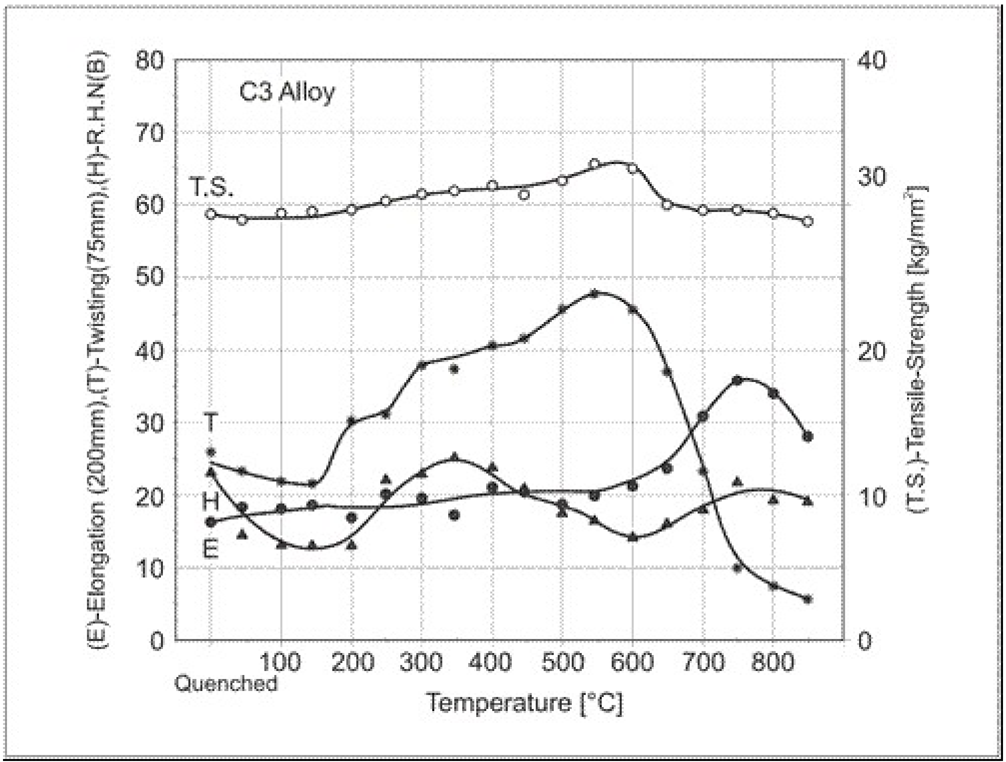
Age-hardening of several Cu-F2P alloys (Specimen D3)[Ref: 649]



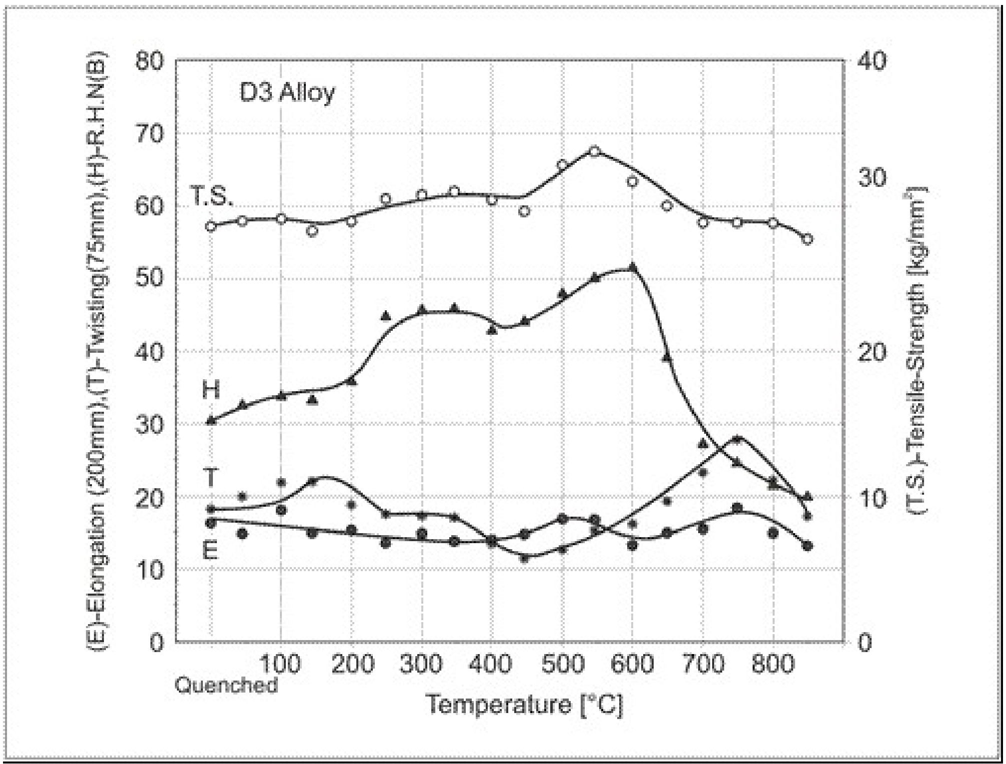
Influence of tempering time on the hardness of specimen C3 quenched from 900°C [Ref: 649]



Influence of tempering time on the hardness of specimen D3 quenched from 900°C [Ref: 649]



Change of mechanical properties (Specimens C3) [Ref: 649]



Change of mechanical properties (Specimens D3) [Ref: 649]

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

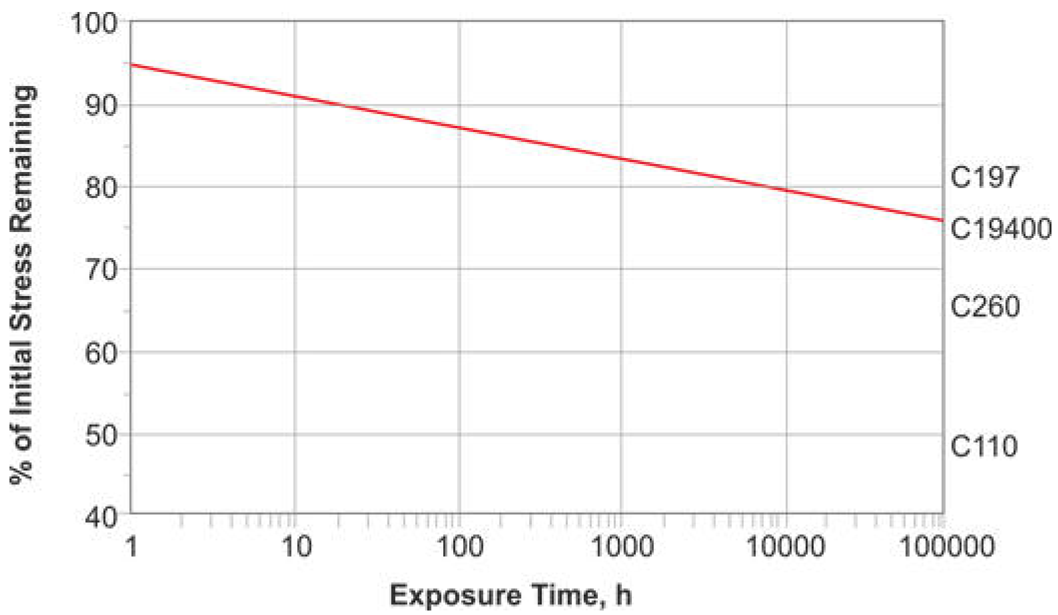
Other kind of corrosion elements

Type of corrosion	Suitability	Literature
Atmospheric	Good	[Ref: 254, 257]
Marine environment	Good	
Stress crack	Good	
Hydrogen embrittlement	Not resistant	
Electrolytic	Fair	

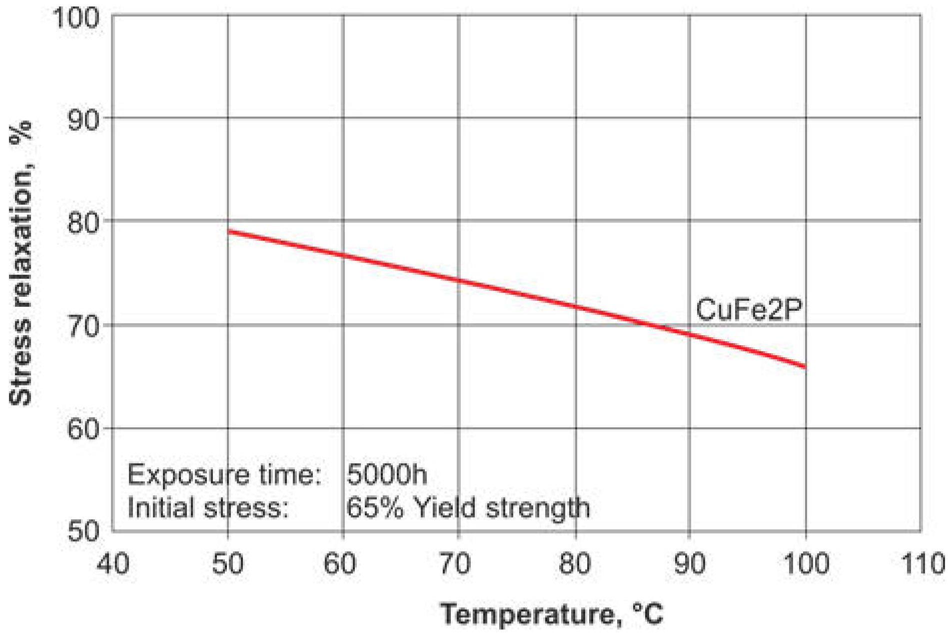
Rheological resistance

Stress relaxation

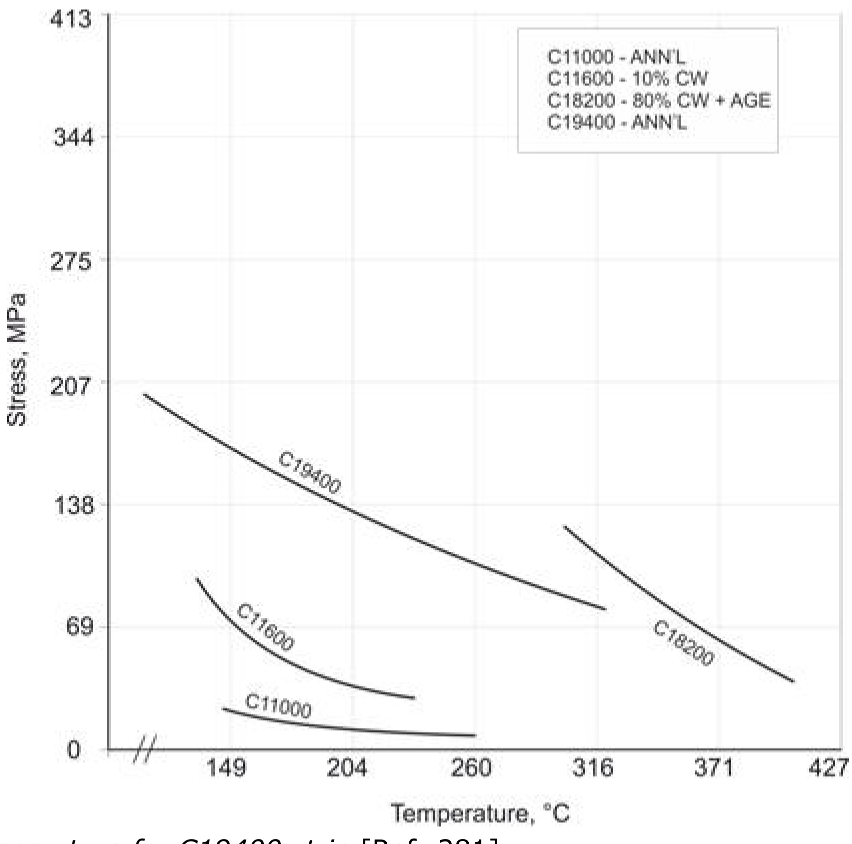
Stress relaxation resistance is critical to the maintenance of contact force over the life of an interconnect and therefore plays a role in the reliability of the system. Alloy C19400 has good stress relaxation resistance to temperatures of 105°C and is superior to copper C11000 and brass C26000.



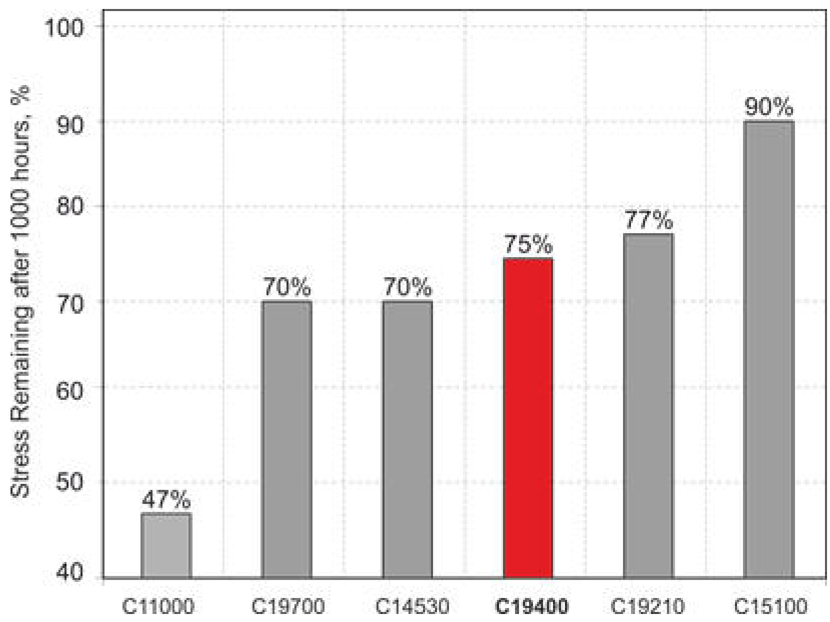
Stress relaxation performance of C19400 (CW107C) (hard (HRO4) selected hard temper copper alloys at 75°C) [Ref: 278]



Stress relaxation behavior of CW107C for different temperatures. Test conditions: initial stress 65% Yield stress, time: 5000 h. [Ref: 278]



Stress vs temperature for C19400 strip [Ref: 281]

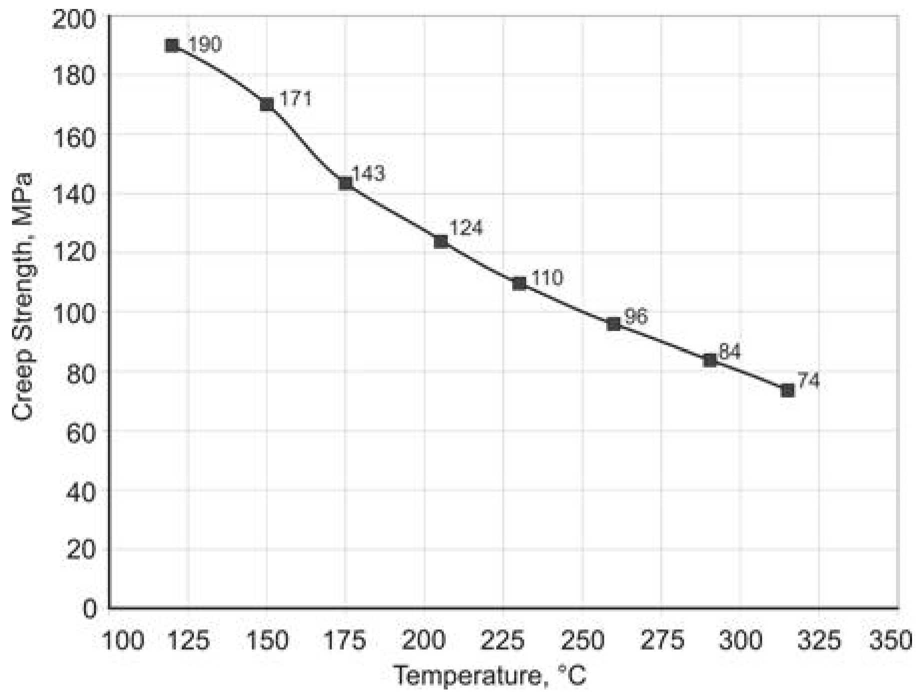


Stress remaining after 1000 hours of high performance copper alloys [Ref: 292]

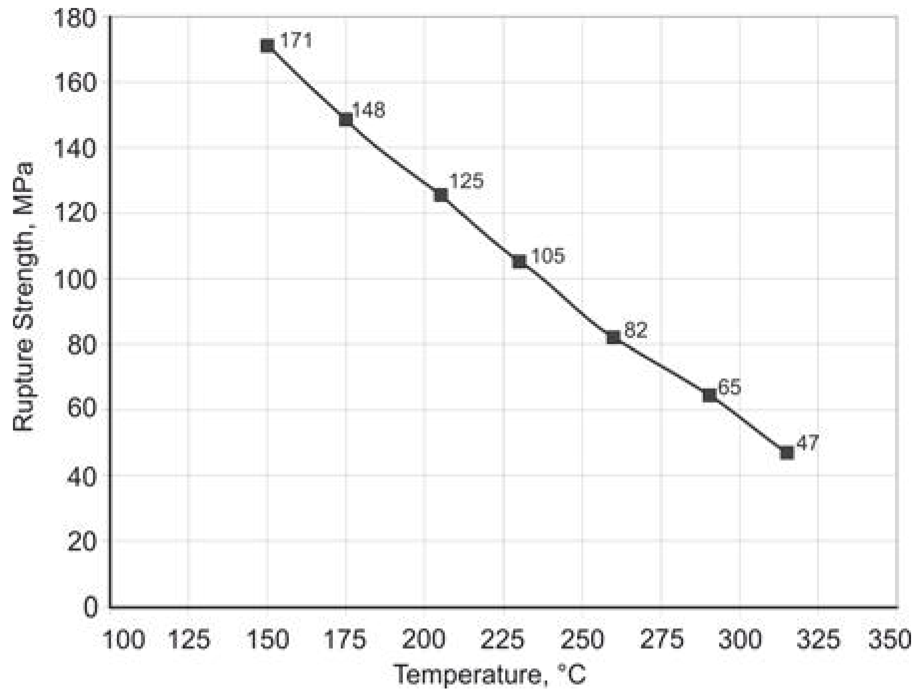
Creep

Creep strength min, MPa properties of annealed C19400 strip (Stress causing creep of 0,01% per 1000h at 10000h test) - [Ref: 270, 255, 275]

	Temperature, °C							
	120	150	175	205	230	260	290	315
Tensile strength, MPa	300	289	276	266	253	235	219	203
Creep strength, MPa	190	171	143	124	110	96	84	74



Creep strength vs temperature [Ref: 254, 257]



Rupture stress vs temperature [Ref: 254, 255]

Wear resistance

Friction resistance

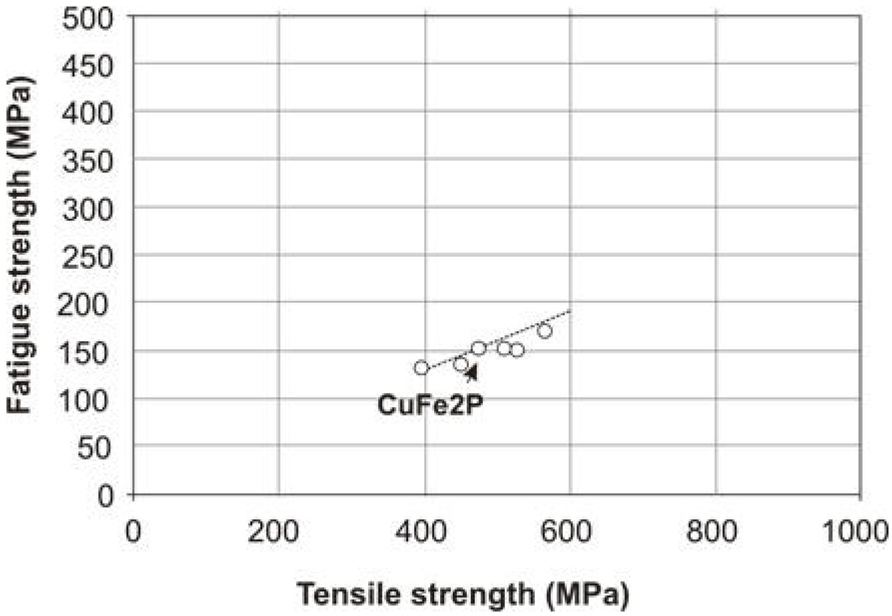
NO DATA AVAILABLE

Fatigue resistance

Fatigue cracking

Fatigue strength vs tensile strength, C19400, H04

Temper	Tensile strength, MPa	Fatigue strength, MPa	Literature
HO4	450	141	[Ref: 254, 257]
HO8	485	145	
H10	505	145	
H14	530	148	
HO4	min 550	141	



Fatigue strength vs tensile strength of C19400 [Ref: 293]

Beandability [Ref: 648]

	H01	H02	H03	H04	H06
0.10<s<0,25> </s<0,25>	Transverse	0 x s	0.5 x s	0.5 x s	0.5 x s
	Parallel	0 x s	0.5 x s	0.5 x s	1.0 x s
0.25<>	Transverse	0 x s	1 x s	1 x s	1.5 x s
	Parallel	0 x s	1.0 x s	2.0 x s	3.0 x s

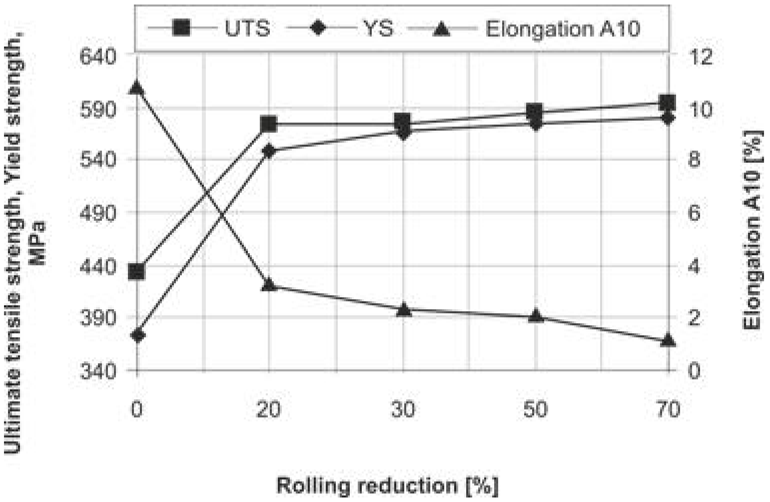
Impact strength

NO DATA AVAILABLE

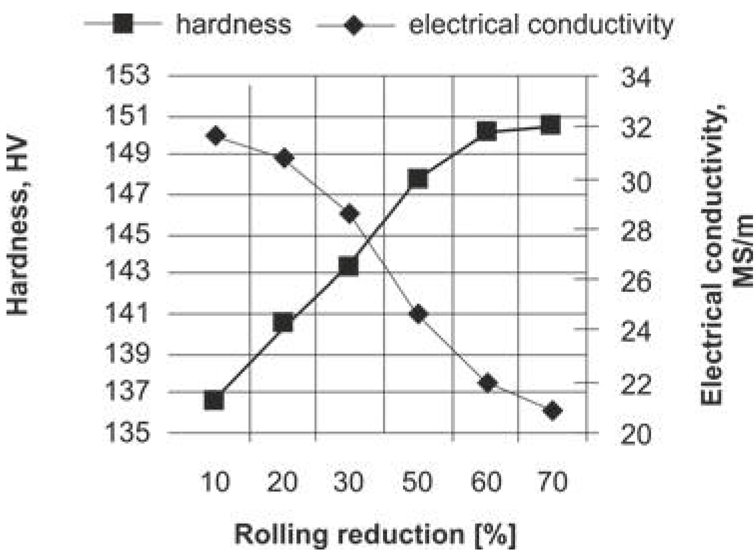
Fabrication properties

Fabrication properties	Value	Comments
Soldering	Excellent	
Brazing	Excellent	
Hot dip tinning	Excellent	
Electrolytic tinning	Excellent	
Laser welding	Good	
Oxyacetylene Welding	Good	
Gas Shielded Arc Welding	Excellent	
Coated Metal Arc Welding	Not Recommended	
Resistance welding	Good	
Spot Weld	Not Recommended	
Seam Weld	Not Recommended	
Butt Weld	Not Recommended	
Capacity for Being Cold Worked	Excellent	
Capacity for Being Hot Formed	Fair	
Forgeability Rating	65	C37700 (forging brass)
Machinability Rating	20-25	C36000 (free-cutting brass)
[Ref: 254, 255, 267]		

Workability - cold working: Initial material was cold worked with rolling reduction:20% (4.0 mm-3.18 mm), 30% (4.0 mm-2.70 mm),50% (4.0 mm-1.94 mm), 70% (4.0 mm-1.22 mm), Then mechanical properties and electrical conductivity were investigated. The results of mechanical properties determinations are presented graphically in Fig. 19 and 20. In Fig. 19 average values of ultimate tensile strength (UTS), yield strength (YS) and elongation (A10) for initial samples (after cold rolling from 15mm to 4.0 mm and annealing) are marked on y-axis. Average UTS value was 434 MPa, average YS value was 373 MPa and average elongation A10 value was 10.8%. It was discovered, that hardness did not change significantly up to 70% of rolling reduction, and for this rolling reduction the lowest electrical conductivity was obtained. [Ref: 283]

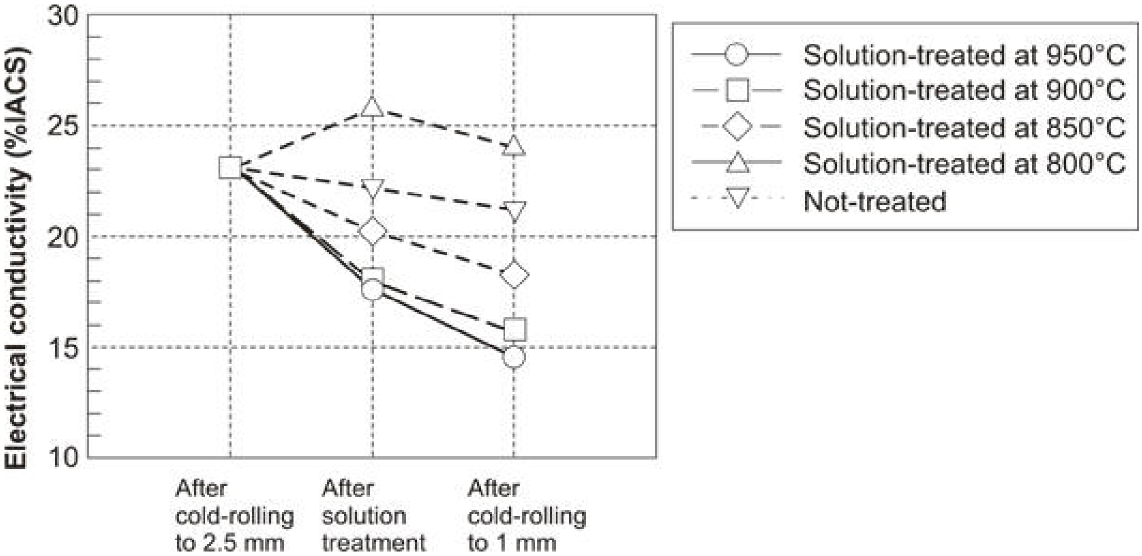


Rolling reduction effect on ultimate tensile strength , yield strength and elongation of CuFe2P [Ref: 283]

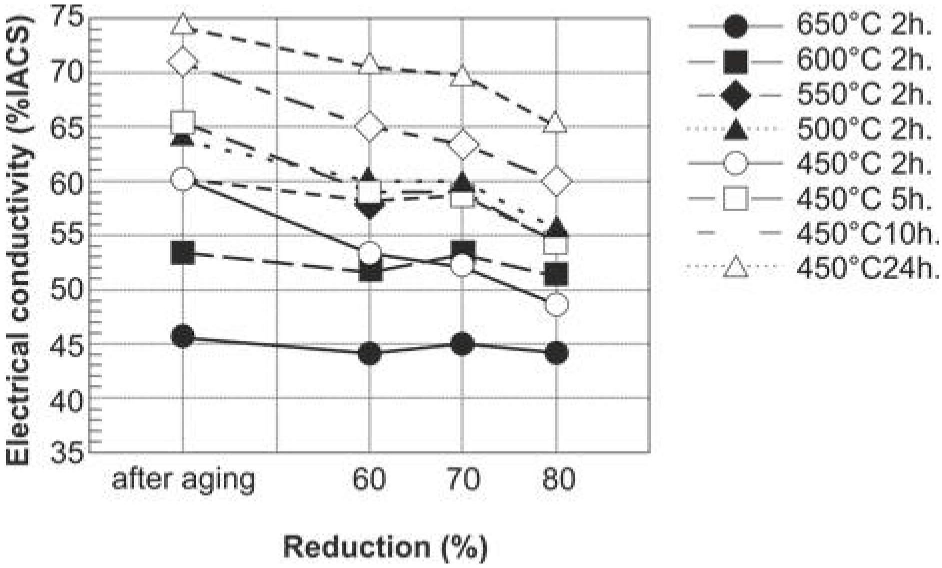


Hardness and electrical conductivity vs rolling reduction of CuFe2P [Ref: 283]

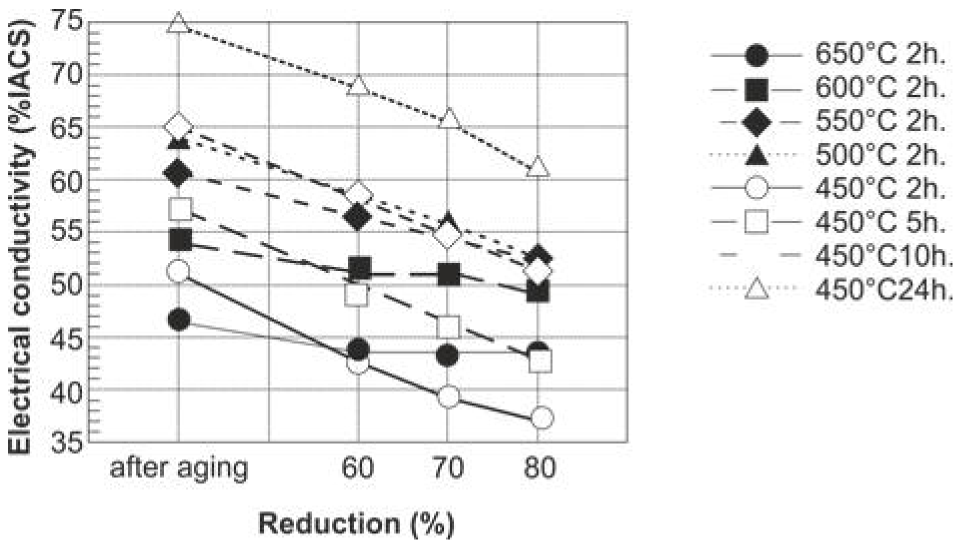
Workability - heat treatment- [7.22]: Specimens 2 mm wide 12 mm thick and 100mm long from the middle of a 12 mm thick hot-rolled strip of C19400 alloy. Their composition: Fe:2,2, P:0,03,Zn:0,12%. The hot rolled specimens were ground to 10 mm in thickness to eliminate the oxidized layer and cold rolled to 2,5 mm in thickness by using a two -roll cold-rolling mill. Next they were solution-treated at 800°C, 900°C and 950°C by immersing them for 1 hour in salt bath and then quenched in water. Then they were cold-rolled to 1 mm in thickness. Next some specimen were not solution-treated, but instead directly cold-rolled to 1 mm in thickness. Temperature of ageing: 450, 500, 550, 600 and 650°C for 2,5,10 and 24 hours.



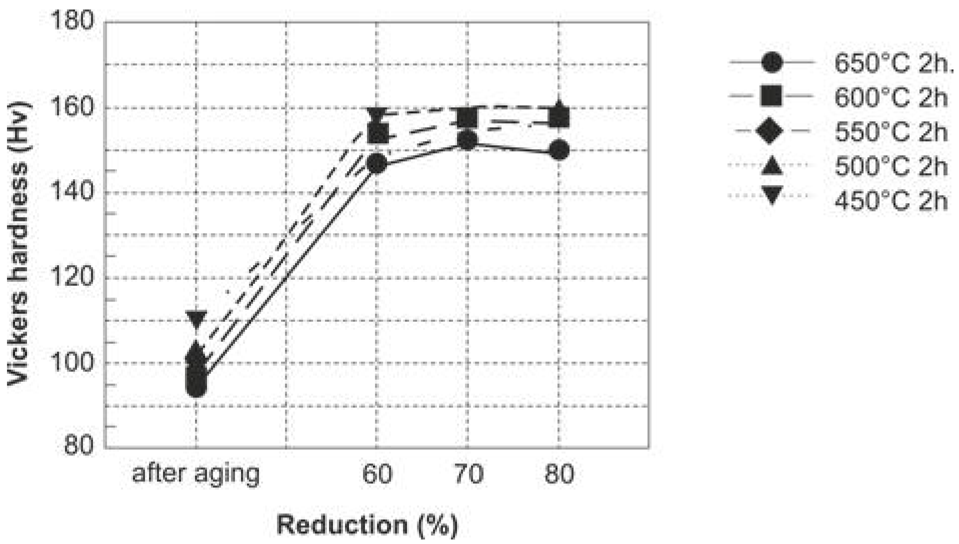
Variation in electrical conductivity after 1st cold rolling after solution treatment and after 2nd cold rolling [Ref: 280]



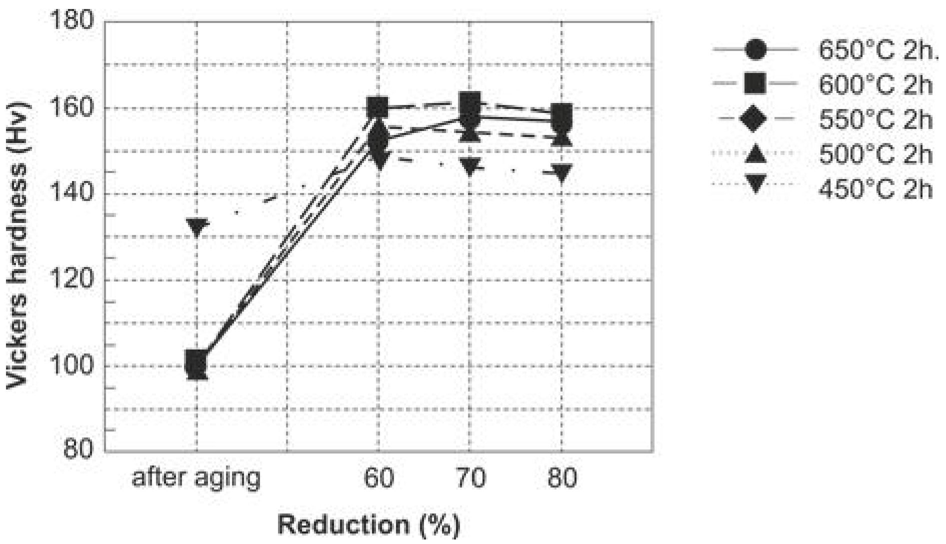
Rate of decrease in electrical conductivity vs % reduction (cold rolling) in different aging temperatures (specimens without solution treatment) [Ref: 280]



Rate of decrease in electrical conductivity vs % reduction (cold rolling) in different aging temperatures(solution treatment 950°C) [Ref: 280]



Vickers hardness after final cold-rolling as a function of reduction (without solution heat treatment) [Ref: 280]



Vickers hardness after final cold-rolling as a function of reduction (solution heat treatment - 950°C) [Ref: 280]

The sheet samples (CuFe2.2P0.05Zn0.16) with 100x10x1.6 mm in thickness were machined from the rectangular cast to solid solution under 850°C for 1 h then hot-rolling, water cooling and cold rolling. Subsequently, the samples were dealt by three-time rolling and two-time aging, that is , first cold rolling, first aging, second cold rolling, second ageing and final fine rolling to sheets about 0.2 mm in thickness and stress-release heat treatment [Ref: 285]

Table Process parameters of thermo-mechanical deformation [Ref: 285]

No	D, mm	FRT, mm	FAT, °C	SRT, mm	SAT, °C	TRT, mm	SRAT, °C
1	1.4	1.0	500	0.5	450	0.2	330
2	1.4	1.0	500	0.3	450	0.2	330
3	1.4	0.8	500	0.4	450	0.2	330
4	1.4	0.8	500	0.3	450	0.2	330
5	1.4	0.65	500	0.3	450	0.2	330
6	1.4	0.65	500	0.25	450	0.2	330
Note: D: for the thickness of starting sample; FRT: for the thickness of samples after first rolling; FAT: for the first aging temperature; SRT: for the thickness of samples after second rolling; SAT: for the second aging temperature; TRT: for the thickness of sample after rolling; SRAT: for the stress release annealing							

The ageing temperatures of thermo-mechanical treatment [Ref: 285]

FAT, °C	SAT, °C	FAT, °C	SAT, °C
550	500	525	500
550	475	525	475
550	450	525	450
550	425	525	425

550	500	475	475
550	475	475	450
550	450	475	425
550	425	475	
Note: FAT: for the first ageing temperature; SAT: for the second ageing temperature			

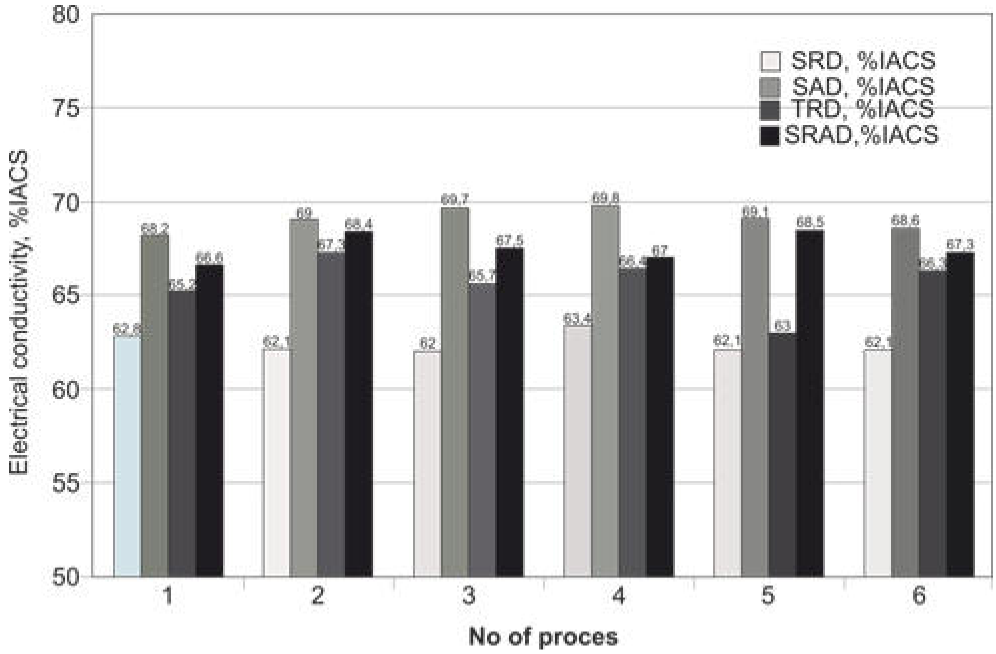


Fig. 26. Electrical conductivity of sheets for diferent technological options [Ref: 285]

The optimized process was as follows: The strip with 1.4 mm thickness was first rolled to 1.0 mm and first aged at 5000C for 2 hours, and second rolled to 0.3 mm and second aged at 450°C for 2 hours, and finally rolled to 0.2 mm and stress-release annealed at 3000C for one hour. The related properties were shown in below table. It was found that final product with relatively good properties , such as the conductivity was 68,5 %IACS and microhardness was 149,9 HV [Ref: 285].

The properties of C19400 alloys manufactured using the optimized process [Ref: 285]

Process	1.4 mm	1.0 mm	500°C/2h	0.3 mm	4500C/2h	0.2 mm	330°Cx1h
Conductivity, %IACS	-	-	-	62.1	69.0	67.3	68.5
Microhardness, HV	119.2	142.4	144.1	159.2	111.6	150.5	149.9

Combination properties of C19400 alloy with various finishing rolling temperatures [Ref: 291]

Finish temperature, °C	Hardness, HV	Elongation, %	Tensile strength, MPa	Electrical conductivity, %IACS

600-650	156	6.4	517	65.4
>750	161	6.9	540	68.5

Technological properties

Technological properties	Value	Comments	Literature
Melting temperature [°C]	1080-1090		[Ref: 267]
Annealling temperature [°C]	450-700 700-815	1-3h	[Ref: 267, 254] [Ref: 267, 254]
Stress relievieng temperature [°C]	200-300	1-3h	[Ref: 267, 254]
Hot working temperature [°C]	800-900 825-950		[Ref: 267, 254] [Ref: 267, 254]

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