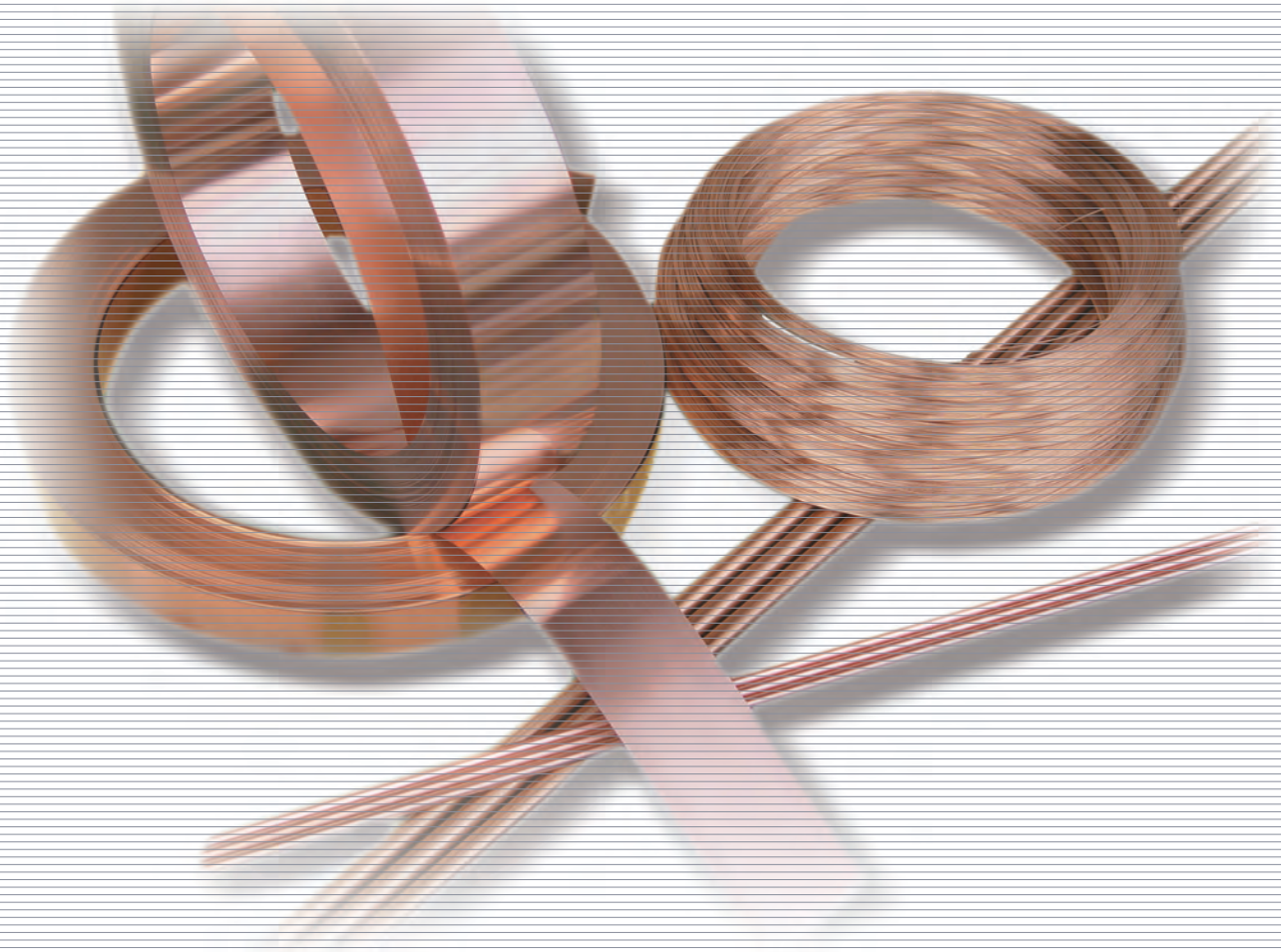
NGK Copper Beryllium



NGK Corporation

New Metals Division

Features of Copper Beryllium

Copper Beryllium is a copper alloy with the optimum combination of mechanical and physical properties such as tensile strength, fatigue strength, performance under elevated temperatures, electrical conductivity, bending formability and corrosion resistance. Copper Beryllium is widely used as contact springs in various applications like connectors, switches, relays, etc. NGK offers a variety of Copper Beryllium alloys in several tempers to cover different applications. Our Copper Beryllium products are available in strip, plate, rod and wire forms.

Tensile Strength

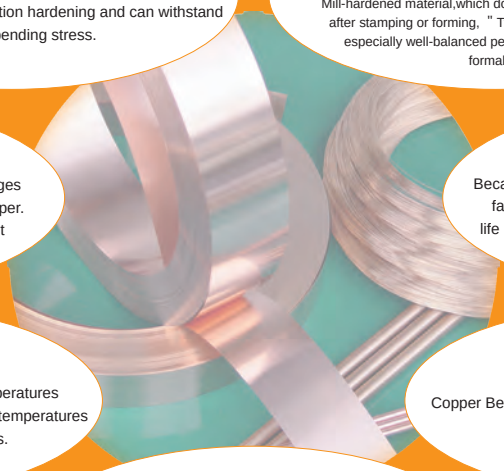
Copper Beryllium can attain the tensile strength of 1500N/mm² through precipitation hardening and can withstand very high bending stress.

Bending Formability

Age hardenable material can be formed into complicated shapes and precipitation hardened afterwards. Among Mill-hardened material,which does not require heat-treatment after stamping or forming, " Type-B " and " Type-S " have especially well-balanced performance in strength and formability.

Electrical Conductivity

The electrical conductivity of beryllium copper ranges from 20 to 70% IACS, depending on alloy and temper. Copper Beryllium is often used as a high current density spring material.



Fatigue Strength

Because Copper Beryllium exhibits excellent resistance to fatigue, it is also used in components where a longer life in service with a cycle stress environment is needed.

Thermal Stability

Due to less stress relaxation at elevated temperatures Copper Beryllium can be used in a wide range of temperatures with little loss of mechanical properties.

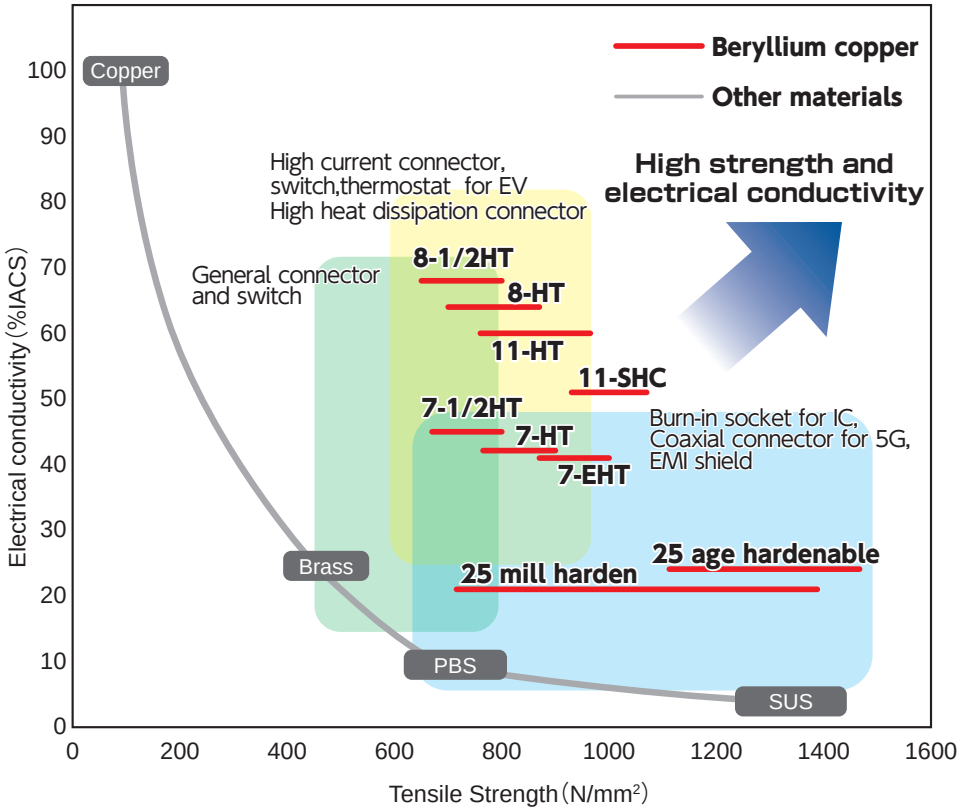
Corrosion Resistance

Copper Beryllium has excellent corrosion resistance, nearly the same as Nickel Silver.

Non-magnetic

Copper Beryllium is suitable for EMC shielding applications. The magnetic permeability is 1/100 of stainless steel (SUS304).

Tensile Strength vs. Electrical Conductivity



Chemical Composition

NGK Alloy	Chemical Composition (wt%)		Major Features	Form
25	Be Ni+Co Ni+Co+Fe Cu+Be+Ni+Co+Fe	1.80-2.00 min. 0.20 max. 0.60 min. 99.5	High strength High Fatigue strength High electrical conductivity Wear resistance Non-magnetic	Strip, Rod/Bar, Wire
8·11	Be Ni Cu+Be+Ni	0.20-0.60 1.40-2.20 min. 99.5	High electrical conductivity High fatigue strength High strength Non-magnetic	
7	Be Ni+Co Al Cu+Be+Ni+Co+Al	0.20-0.40 1.80-2.50 max. 0.60 min. 99.0		Strip

The chemical composition of beryllium copper alloys is tested using luminescence spectrometry in the manner specified by our company. Cu is the residue minus major and trace elements.

Physical Properties *

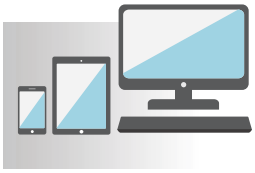
Item			NGK Alloy 25	NGK Alloy 8·11	NGK Alloy 7
Melting Point (solidus)	˚C		865	1004	1050
Melting Point (liquidus)	˚C		980	1070	1081
Density	g/cm^3	at 20˚C	8.36	8.82	8.71
Specific Heat	J/(kg•K)	at 20˚C	419	419	419
Thermal Expansion Coefficient	/ ˚C	at 20～300˚C	17.8×10^{-6}	17.6×10^{-6}	17.6×10^{-6}
Modulus of Elasticity	kN/mm^2		127	132	127
Modulus of Rigidity	kN/mm^2		49	52	49
Poidon's Ratio			0.3	0.3	0.3
Magnetic Permeability	μ(μ=1+4πk)		1.000042	1.000031	1.000027

Electrical conductivity and thermal conductivity *(at 20℃)

	NGK Alloy 25		NGK Alloy 8		NGK Alloy 11		NGK Alloy 7		
	Age Hardenable	Mill hardened	8-1/2HT	8-HT	11-HT	11-SHC	7-1/2HT	7-HT	7-EHT
Thermal conductivity W/(m・K)	99	85	298	280	262	221	194	180	176
Electrical conductivity (%IACS)	24	21	68	64	60	51	45	42	41

Physical properties and Electrical conductivity, thermal conductivity are for reference only.

Properties and Applications







Properties for Strip applications at a glance

Alloy	Properties	Applications								Reference standards				
		connectors	IC sockets	switches	relays	micro motor	Jacks	thermostat	EMI shield	ASTM	CDA	EN	JIS	YS/T
High Strength	25 ➡p.05,06	Having the highest strength among copper alloys for spring material, this alloy is most suitable for the applications that require high reliability as an electrical contact	●	●	●	●	●	●	●	●	B194 C17200	C17200	1652 CuBe2 1654 CuBe2	H3130 C1720	TBe1.9-0.2
High electrical conductivity	8・11 ➡p.07	These alloys are superior to phosphor bronze in strength and have electrical conductivity more than 50% IACS	●	●		●		●	●	●	B534 C17510	C17510	1652 CuNi2Be	H3130 C1751	TBe0.4-1.8
Midrange	7 ➡p.08	This alloy has higher mechanical properties than phosphor bronze and has good bending formability at the same time. Also good performance in cost saving.	●	●	●	●		●	●	●		C17530			

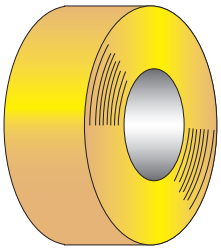
Properties for Rod applications at a glance

Alloy	Properties	Applications						Reference standards			
		co-axial connectors	coil spring	contact probe	electrode	lens suspension	wiring harness	ASTM	CDA	EN	JIS
High Strength	25 ➡p.09	Having the highest strength among copper alloys for spring material, this alloy is most suitable for the applications that require high strength.	●	●	●	●	●	●	B196 C17200 B197 C17200	C17200	12163 CuBe2	H3270 C1720
High electrical conductivity	11 ➡p.09	These alloys are superior to bronze in strength and have electrical conductivity more than 50% IACS			●		●	●	B442 C17510	C17510	12163 CuNi2Be	

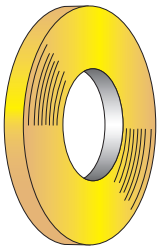
※The alloy names, product names, and standard names mentioned on this page are used for convenience to indicate the relationship between our products and the types of products specified in each standard, and do not indicate that the materials and test methods of our products conform to or comply with each regulation.

Forms of Copper Beryllium Products

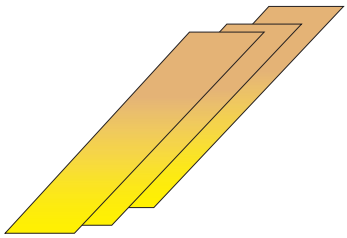
Strip: Range of Standard Production



Mill width coil



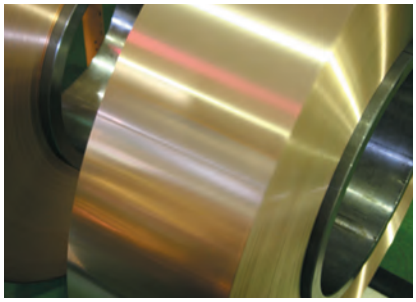
Slit coil



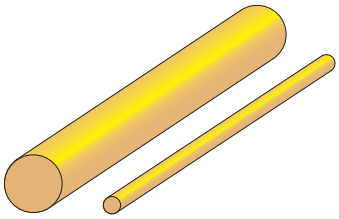
Cut to length

Coil	Thickness	0.050 - 2 mm
	Width	max. 200 mm
Cut to length	Thickness	0.050 - 1.0 mm
	Length	max. 1200 mm

※Alloy 7 and 8 are available in standard thickness dimensions.
※Please contact us for special requirement.
※The range may vary depending on alloy and temper.

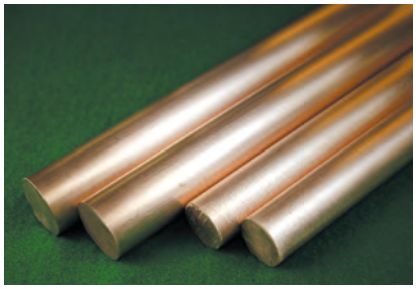


Rod: Range of Standard Production

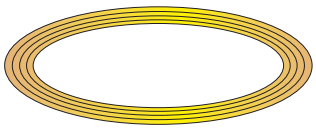


Round rod

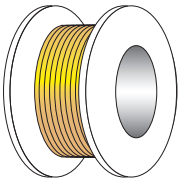
Diameter	1-120 mm



Wire: Range of Standard Production

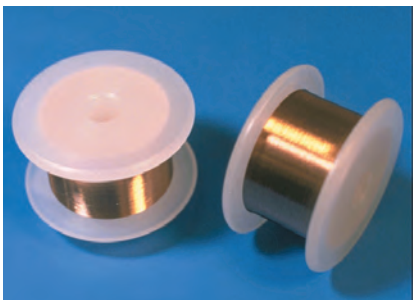


in coil



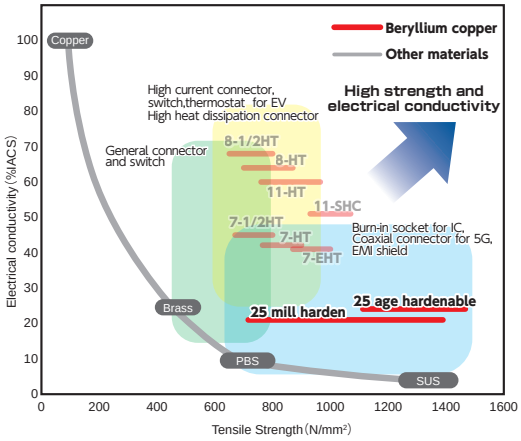
on bobbin

Diameter	in coil	0.2 - 7.0 mm
	on bobbin	0.05 - 0.15 mm



Mechanical Properties of High Strength Material

Alloy 25



Properties of Strip

Alloy		Temper	Designation [5]	Tensile test [1]			Hardness test	Electrical conductivity [2]	Heat [6]
				Tensile strength (N/mm²)	Yield strength 0.2% offset (N/mm²)	Elongation (%)	Vickers hardness HV	(%IACS)	treatment
25	Age Hardenable [6]	O	C1720$^{P}_{R}$—O	410-540	—	min. 30	90-160	—	—
		OT	C1720$^{P}_{R}$—OT	1100-1380 [3]	min. 960	min. 3	350-400	min. 22	180min at 315°C
		1/4H	C1720$^{P}_{R}$—1/4H	510-620	—	min. 10	145-220	—	—
		1/4HT	C1720$^{P}_{R}$—1/4HT	1180-1400 [3]	min. 1030	min. 2	360-430	min. 22	150min at 315°C
		1/2H	C1720$^{P}_{R}$—1/2H	590-695	—	min. 5	180-240	—	—
		1/2HT	C1720$^{P}_{R}$—1/2HT	1240-1440 [3]	min. 1100	min. 2	370-440	min. 22	120min at 315°C
		H	C1720$^{P}_{R}$—H	685-835	—	min. 2	210-270	—	—
		HT	C1720$^{P}_{R}$—HT	1270-1480 [3]	min. 1140	min. 1	380-450	min. 22	120min at 315°C
	Mill haddened (Standard) [6]	1/4HM [7]	C1720$^{P}_{R}$—1/4HM	735-930 [4]	min. 550	min. 10	235-285	min. 17	—
		1/2HM [7]	C1720$^{P}_{R}$—1/2HM	815-1010 [4]	min. 650	min. 8	260-310	min. 17	—
		HM	C1720$^{P}_{R}$—HM	910-1110 [4]	min. 750	min. 6	295-345	min. 17	—
		XHM	C1720$^{P}_{R}$—XHM	1100-1290 [4]	min. 930	min. 2	340-390	min. 17	—
		XHMS	C1720$^{P}_{R}$—XHMS	1210-1400 [4]	min. 1030	min. 2	360-410	min. 17	—
	Mill haddened Type B (Good formability) [6]	1/4HMB [7]	C1720$^{P}_{R}$—1/4HMB	760-860 [4]	550-760	min. 15	215-280	min. 16	—
		1/2HMB [7]	C1720$^{P}_{R}$—1/2HMB	830-930 [4]	660-860	min. 12	255-310	min. 16	—
		HMB	C1720$^{P}_{R}$—HMB	930-1030 [4]	760-930	min. 9	280-340	min. 17	—
		XHMB	C1720$^{P}_{R}$—XHMB	1070-1210 [4]	930-1170	min. 4	330-390	min. 17	—

1) Yield strength 0.2% offset and Elongation values are applicable to thickness 0.1mm and over. 2) Electrical conductivity is for design guidance only.
3) The upper limits of tensile strength after age hardening are for design guidance only. 4) The upper limits of tensile strength of mill hardened strip are for design guidance only.
6) Rolerance of heat treatment temperature shall be ± 5 degC, and tolerance of heat treatment time shall be ± 10 minutes. 7) Contact us for purchase instructions.

Tolerances

Thickness tolerance (mm)

Specified thickness		Tolerance
Over	Up to and including	
from 0.050	0.08	±0.004
0.08	0.1	±0.005
0.1	0.15	±0.006
0.15	0.2	±0.008
0.2	0.25	±0.010
0.25	0.4	±0.015
0.4	0.55	±0.020
0.55	0.7	±0.025
0.7	0.9	±0.030
0.9	1.2	±0.035
1.2	1.5	±0.045
1.5	2.0	±0.050

Width tolerance (mm)

Specified width / Specified thickness		Tolerance		
		Strip cut to length	Strip in coils	
Over	Up to and including	max. 200	max. 100	Over 100 up to and including 200
from 0.050	0.55	+2 −0	±0.1	±0.2
0.55	1.0	+2 −0	±0.2	±0.3
1.0	2.0	−	±0.2	±0.3

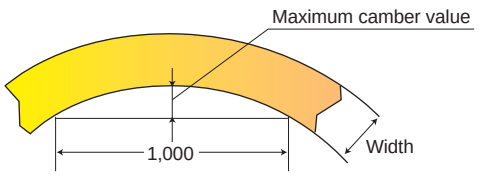
note) When the tolerance is specified either plus or minus side only, the sama range of tolerance shall be applied.
Please contact us for special thickness.

Length tolerance (mm)

Specified thickness / Specified length		Tolerance
Over	Up to and including	max. 1000
from 0.05	0.55	+8 −0
0.55	1.0	+10 −0

Camber tolerance (mm)

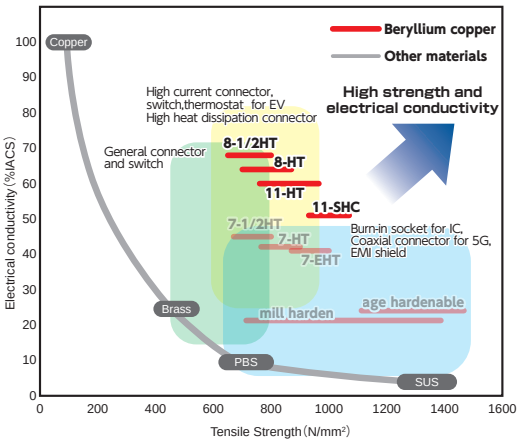
Specified width		Maximum value
Over	Up to and including	Over 1000 length
from 4	13	4
13	50	3
50	100	2
100	200	1



*Please note that the contents of this catalog are subject to change without notice.

Mechanical Properties of High Electrical Conductivity Material

Alloy 8 & Alloy 11



Properties of Strip

Alloy	Temper	Designation [4]	Tensile test [1]			Hardness test	Electrical conductivity [2] (%IACS)
			Tensile strength (N/mm²)	Yield strength 0.2% offset (N/mm²)	Elongation (%)	Vickers hardness HV	
8	1/2HT	BeCu P/R 08-1/2HT	650-800 [3]	min. 550	min. 10	180-230	min. 60
	HT [5]	BeCu P/R 08-HT	700-870 [3]	min. 600	min. 5	210-260	min. 60
11	HT	BeCu P/R 11-HT	760-965 [3]	min. 655	min. 5	230-280	min. 50
	SHC	BeCu P/R 11-SHC	930-1070 [3]	min. 850	min. 5	280-330	min. 45

1) Yield strength 0.2% offset and Elongation values are applicable to thickness 0.1mm and over. 2) Electrical conductivity is for design guidance only.
3) The upper limits of tensile strength are for design guidance only. 4) P and R in column "Designation" represent "strip cut to length" and "strip in coils". 5) Contact us for purchase instructions.

Tolerances

Thickness tolerance (mm)

Thickness	Tolerance
0.06 up to 0.08	±0.005
over 0.08 up to 0.10	±0.006
〃 0.10 〃 0.15	±0.008
〃 0.15 〃 0.20	±0.009
〃 0.20 〃 0.25	±0.010
〃 0.25 〃 0.40	±0.015
〃 0.40 〃 0.55	±0.020
〃 0.55 〃 0.70	±0.025
〃 0.70 〃 0.90	±0.030
0.90 less then 1.2	±0.040

note) Lower limit thickness: 8-1/2HT 0.1mm, 11HT 0.08mm

Width tolerance (mm)

Specified thickness: Over	Specified thickness: Up to and including	Specified width: Tolerance — Strip cut to length: max. 200	Strip in coils: max. 100	Strip in coils: Over 100 up to and including 200
from 0.08	0.55	+2 −0	±0.1	±0.2
0.55	1.0	+2 −0	±0.2	±0.3
1.0	2.0	-	±0.2	±0.3

note) Lower limit thickness: 8-1/2HT 0.1mm, 11HT 0.08mm

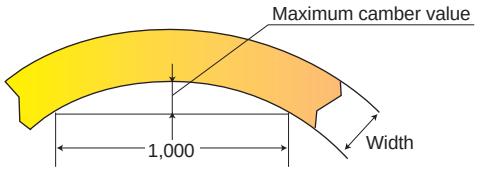
Length tolerance (mm)

Specified thickness: From	Specified thickness: Up to and including	Specified length: Tolerance — max. 1200
0.08	1.0	+10 − 0

note) Lower limit thickness: 8-1/2HT 0.1mm, 11HT 0.08mm

Camber tolerance (mm)

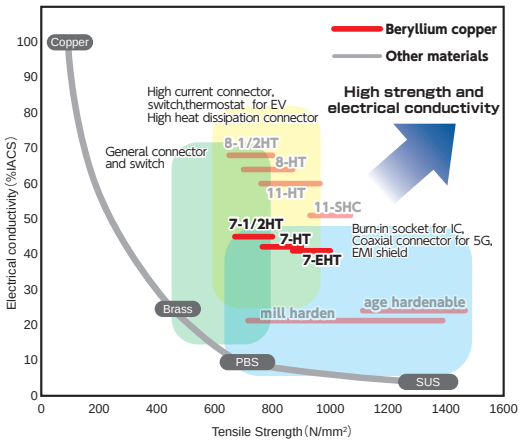
Specified width: Over	Specified width: Up to and including	Maximum value: Over 1000 length
from 4	13	4
13	50	3
50	100	2
100	200	1



*Please note that the contents of this catalog are subject to change without notice.

Mechanical Properties of Midrange Material

Alloy 7



Properties of Strip

Alloy	Temper	Designation [4]	Tensile test [1]			Hardness test	Electrical conductivity [2] (%IACS)
			Tensile strength (N/mm²)	Yield strength 0.2% offset (N/mm²)	Elongation (%)	Vickers hardness HV	
7	1/2HT	$BeCu^{P}_{R}$07-1/2HT	670-800	550-760	min. 10	195-250	min. 38
	HT	$BeCu^{P}_{R}$07-HT	765-900	686-834	min. 8	220-275	min. 33
	EHT	$BeCu^{P}_{R}$07-EHT	870-1000	750-930	min. 4	250-310	min. 30

1) Yield strength 0.2% offset and Elongation values are applicable to thickness 0.1mm and over. 2) Electrical conductivity is for design guidance only.
3) The upper limits of tensile strength are for design guidance only. 4) P and R in column "Designation" represent "strip cut to length" and "strip in coils".

Tolerances

Thickness tolerance

Standard thickness iz onry available for Alloy 7. (mm)

Specified thickness	Tolerance
0.08	±0.006
0.10	±0.006
0.12	±0.006
0.15	±0.008
0.18	±0.010
0.20	±0.010
0.25	±0.010
0.30	±0.015
0.35	±0.015
0.40	±0.015

Width tolerance (mm)

Thickness \ Specified width	Tolerance		
	Strip cut to length	Strip in coils	
	max. 200	max. 100	Over 100 up to and including 200
from 0.08 up to 0.40	+2 −0	±0.1	±0.2

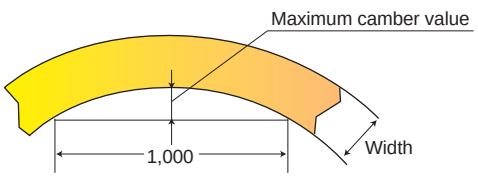
note) When the tolerance is specified either plus or minus side only,the same range of tolerance shall be applied.

Length tolerance (mm)

Specified thickness \ Specified length		Tolerance
From	Up to and including	max. 1000
0.08	0.4	+10 − 0

Camber tolerance (mm)

Specified width		Maximum value
Over	Up to and including	Over 1000 length
from 4	13	4
13	50	3
50	100	2
100	200	1



*Please note that the contents of this catalog are subject to change without notice.

Properties of Rod and Wire

Alloy 25 & Alloy 11

Properties of Rod

Alloy	Temper		Diameter (mm)	Tensile strength (N/mm^2)	Rockwell Hardness		Electrical Conductivity (%IACS)
					H_RB	H_RC	
25	A(O)	C1720B–A	From 1 up to 13 over 13 up to 120	410 – 590 —	— 45 – 85	— —	min. 17 min. 17
	AT(OT)	C1720B–AT	From 1 up to 13 over 13 up to 120	1100 – 1380 —	— —	— 36 – 42	min. 22 min. 22
	H	C1720B–H	From 1 up to 6 over 6 up to 13.3	645 – 900 —	— 88 – 103	— —	min. 15 min. 15
	HT	C1720B–HT	From 1 up to 6 over 6 up to 13.3	1270 – 1650 —	— —	— 37 – 45	min. 22 min. 22
11	AT(OT)	BeCuB11–AT	over13.3 up to 120	—	92 – 105	—	min. 45
	HT	BeCuB11–HT	from 1 up to 6 over 6 up to 13.3	760 – 965 —	— 92 – 105	— —	min. 50

1) B in column "Designation" represents "bar" or "rod" 2), 3) If hardness specification is designated, tensile test will not be applied.
4) Vickers hardness and electrical conductivity are for design guidance only.
note) Please contact us if you want to heat treat a material A or H after purchasing.

Properties of Wire

Alloy	Temper		Diameter (mm)	Tensile Strength (N/mm^2)	Electrical conductivity (%IACS)	Heat treatment
25	3/4H	C1720W–3/4H	from 0.1 up to 7	835 – 1070	—	Before aging
	3/4HT	C1720W–3/4HT	—	1300 – 1590	min. 22	120min at 315°C
	EH	C1720W–EH	form 0.05 up to 0.4	min. 1200	—	Before aging
	EHT	C1720W–EHT	—	min. 1500	min. 22	60min at 260°C

1) W in column "Designation" represents "Wire" 2) Electrical conductivity are for design guidance only.

Diameter Tolerance of Rod and Wire

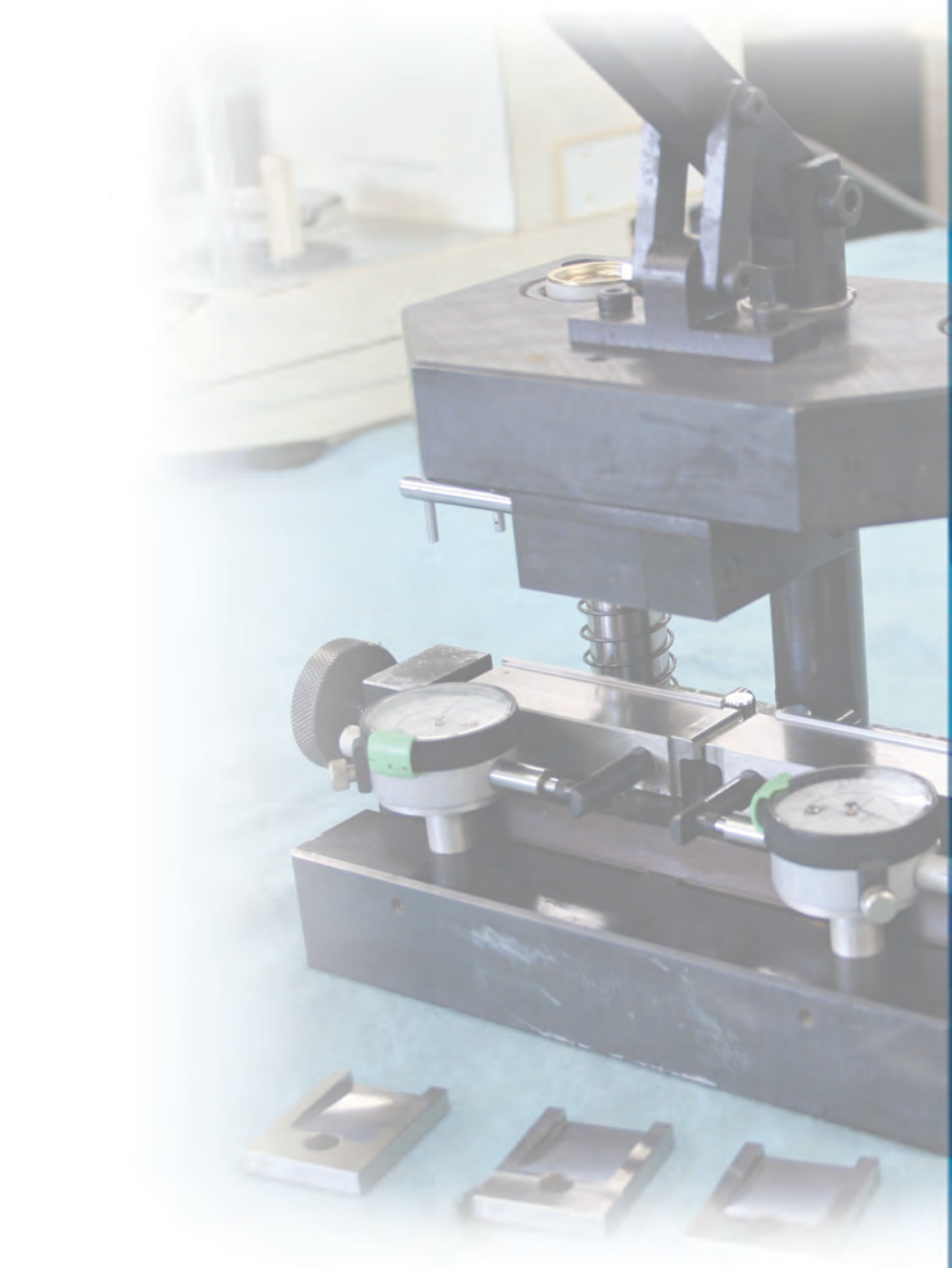
rod				wire	
25A and H, 11AT and HT		25AT and HT		25	
Nominal diameter (mm)	tolerance	Nominal diameter (mm)	tolerance	Nominal diameter (mm)	tolerance
1 up to 5	±0.01	1 up to 5	±0.01	0.05 less than 0.10	±0.003
over 5 up to 13.3	±0.02	over 5 up to 13.3	±0.02	0.10 up to 0.25	±0.005
over 13.3 up to 20	±0.08	over 13.3 up to 20	±0.08	over 0.25 up to 0.3	±0.008
over 20 up to 35	±0.10	over 20 up to 35	±0.10	over 0.3 up to 0.5	±0.010
Alloy 25: over 35 up to 55 Alloy 11: over 35 up to 50	±0.12	over 35 up to 55	±0.12	over 0.5 up to 1	±0.015
Alloy 25: over 55 up to 120 **up to 94 for 25H temper Alloy 11: over 50 up to 120	+1/-0	Alloy 25: over 55 up to 120 **up to 94 for 25H temper	+1/-0	over 1 up to 2	±0.020
				over 2 up to 5	±0.025
				over 5 up to 7	±0.030

note) When the tolerance is specified either plus or minus side only,the same range of tolerance shall be applied.

*Please note that the contents of this catalog are subject to change without notice.

Copper Beryllium Technical Report

This technical report is for reference only.
Please contact us if you need further information. We are pleased to propose a suitable material considering your requirements.



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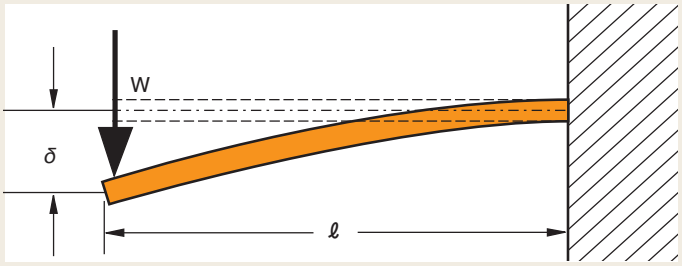
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Spring properties and Downsizing

Copper Beryllium is the ideal spring material because of its high mechanical strength and favorable elastic modulus.

The elastic modulus is a common term for the modulus of longitudinal elasticity and is also known as Young's modulus. This value is the slope of the linear portion of the stress-strain curve obtained by a tensile test. Elastic modulus can also be measured directly in the case of a thin flat spring. Fig. 1 shows the formula for surface stress and spring load in cantilever system. Elastic modulus is one of the important constants for designing contact springs for connectors and switches. In general, if the value is too large, contact force varies greatly with a slight movement of a contact. On the contrary, if it is too small, required contact force cannot be obtained.

Since the ratio of yield strength to Young's modulus of copper beryllium is greater than stainless steel and phosphor bronze, larger displacement and higher contact force can be obtained. Making full use of copper beryllium spring properties, we can downsize a phosphor bronze spring part while the contact force remains the same. This may also lead to downsizing of plastic parts or terminals around it, thus, we can expect cost saving in total.



t : Thickness (mm)

b : Width (mm)

ℓ : Length (mm)

E : Young's Modulus (N/mm²)

δ : Deflection (mm)

σ : Surface stress (N/mm²)

$$\sigma = \frac{3\delta Et}{2\ell^2}$$

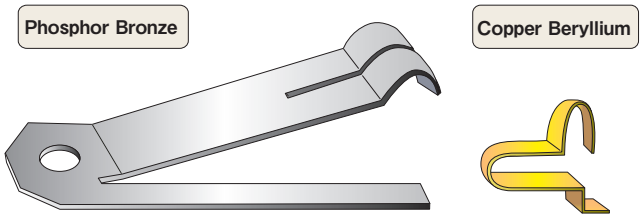
W : Spring load (N)

$$W = \frac{\delta Ebt^3}{4\ell^3}$$

Fig. 1 Surface Stress and Spring Load in Cantilever System

Due to the high tensile strength up to 1,500N/mm², copper beryllium is used to reduce the pitch of contact arrays without deterioration of spring performance. A connector in a given housing space can be designed to a higher density than with any other copper alloy. In conclusion we can reduce the cost per pin compared to phosphor bronze.

Fig. 2 shows an example of downsizing in the design of a battery contact using copper beryllium. Due to the reduction of material input and surface area to be plated, total cost compared with phosphor bronze can be lower.



Material	Phosphor Bronze C5210-EH	Copper Beryllium C1720R-HMB
Part weight (g)	1.14	0.14
Ratio	1	0.12

Fig. 2 Downsizing of Battery Contact

Potential of Copper Beryllium

Formability

The temper of age hardenable material ranges from "O", suitable for deep drawing, to "H", cold rolled to obtain high strength with moderate formability. However, as the cold reduction rate increases, material tends to exhibit some anisotropy.

It is one of the key factors to choose the highest temper that can be formed in order to optimize the performance and efficiency of a spring part. This also improves dimensional stability during heat treatment.

Although mill-hardened material is not fully aged, it did pass through an aging process. Therefore, it is necessary to consider formability when you choose the temper. For critical bending, mill-hardened Type-B are suitable.

The ratio of the inside bend radius "R" to the thickness "t" is relative formability (See Fig.3). In 90° bending, the test specimen is placed upon the V-block with 90° concave angle and force is applied with a tool so that the specimen will have a right angle bend. The minimum inside radius where no micro crack or intensive orange peel is generated on the outside of the bending point represents "R," and "t" is the material thickness.

Table 1 to 3 show the relative formability of NGK copper beryllium strip. Relative formability slightly changes depending on the thickness, i.e. thinner strip tends to have smaller R/t value. These table show the typical value in thickness 0.15mm.

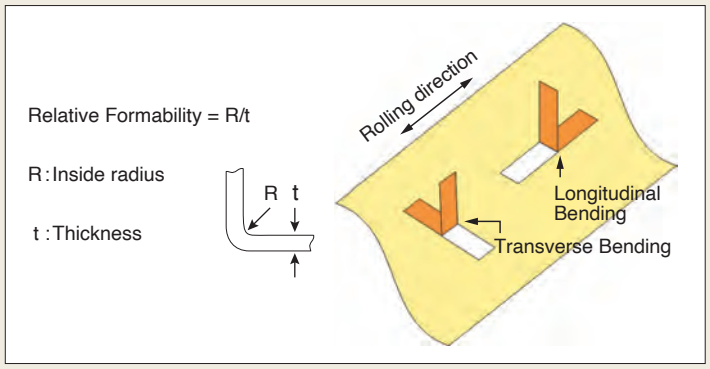
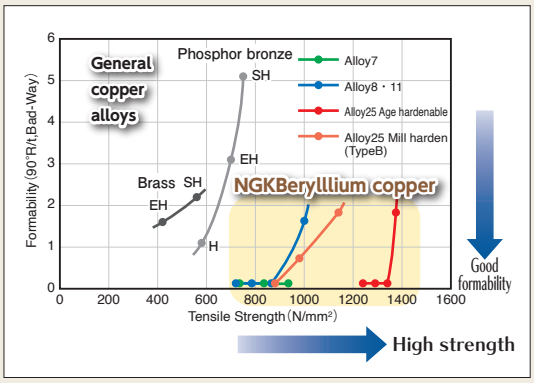


Fig. 3 Relative Formability R/t



Note: The test method is 90° bend test in accordance with JIS H 3130:2025, and the evaluation is based on the Japan Copper and Brass Association technical standard JCBA T307.

Table 1 Relative Formability of High Strength Material (90° bending)

Alloy	Type	Temper	R/t thickness≤0.5mm		Typical R/t in thickness 0.15mm	
			Long.	Trans.	Long.	Trans.
25	AH	O	0.0	0.0	0.0	0.0
		1/4H	1.0	2.0	0.0	0.0
		1/2H	2.0	3.0	0.0	0.0
		H	2.0	6.0	0.0	1.7
	MH	OM	0.8	2.0	0.0	0.6
		1/4HM	1.0	3.0	0.3	1.0
		1/2HM	2.0	4.0	0.6	2.7
		HM	3.0	6.0	1.0	4.0
		XHM	4.0	—	3.0	—
		XHMS	6.0	—	4.0	—
	MH TypeB	OMB	0.8	0.8	0.0	0.0
		1/4HMB	1.0	1.0	0.0	0.0
		1/2HMB	1.3	1.3	0.0	0.0
		HMB	2.5	2.5	0.6	0.6
		XHMB	3.4	3.8	1.7	1.7

Table 2 Relative Formability of High conductive Material (90° bending)

Alloy	Temper	R/t thickness≤0.5mm		Typical R/t in thickness 0.15mm	
		Long.	Trans.	Long.	Trans.
8	HT	1.0	1.0	0.0	0.0
	1/2HT	0.5	0.5	0.0	0.0
11	HT	2.0	2.0	0.0	0.0
	SHC	3.5	3.5	1.5	1.5

Table 3 Relative Formability of Midrange Material (90° bending)

Alloy	Temper	R/t thickness≤0.5mm		Typical R/t in thickness 0.15mm	
		Long.	Trans.	Long.	Trans.
7	1/2HT	0.0	0.0	0.0	0.0
	HT	1.5	1.5	0.0	0.0
	EHT	2.0	1.5	0.3	0.0

Thermal Stability

Copper Beryllium is widely used in electrical components such as connectors, switches and relays. Spring parts in these components need to keep the contact force reliable over a long period of time. In addition, they are often exposed to the effect of heat. The heat may be due to environmental conditions, or self heating by electric current. Loss of contact force may occur due to stress relaxation.

Fig. 4 represents stress relaxation of copper beryllium and phosphor bronze. Stress relaxation is measured on test specimens which are fixed as shown in Fig. 4 and are exposed to the heat under designated conditions of temperatures and periods of time. The permanent set of each test specimen is measured and converted into loss of force value.

Copper beryllium exhibits far less stress relaxation and much better performance in heat resistance than phosphor bronze.

Stress relaxation is a kind of creep phenomena. Since it is not practical to monitor the material behavior over a long period of time, we usually estimate the behavior based on the test results for a shorter period of time. Because of the high accuracy the Larson-Miller method is commonly used.

Equation (1) shows the Larson-Miller's experimental formula.

$$\left(\frac{9}{5}T+492\right)(20+\log t)\times 10^{-3}=P\cdots\cdots(1)$$

T: Temperature˚C

t: Exposure Time hrs.

Fig. 5 shows a relationship between remaining stress of copper beryllium and Larson-Miller's parameter "P". From this curve, "P" corresponding to given remaining stress is obtained, and we can estimate remaining stress under the combination of temperature and exposure time necessary for the design.

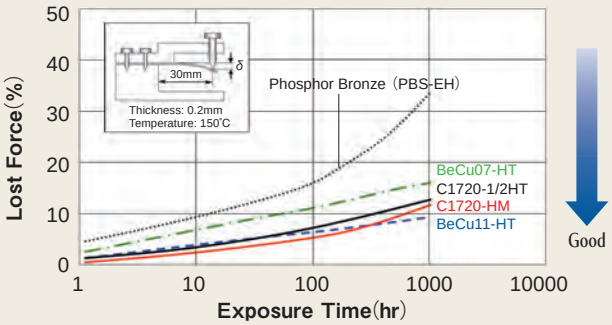


Fig. 4 Stress Relaxation of Copper Beryllium in comparison with Phosphor Bronze

Note : The test method is based on the Japan Copper and Brass Association technical standard JCBA T309.

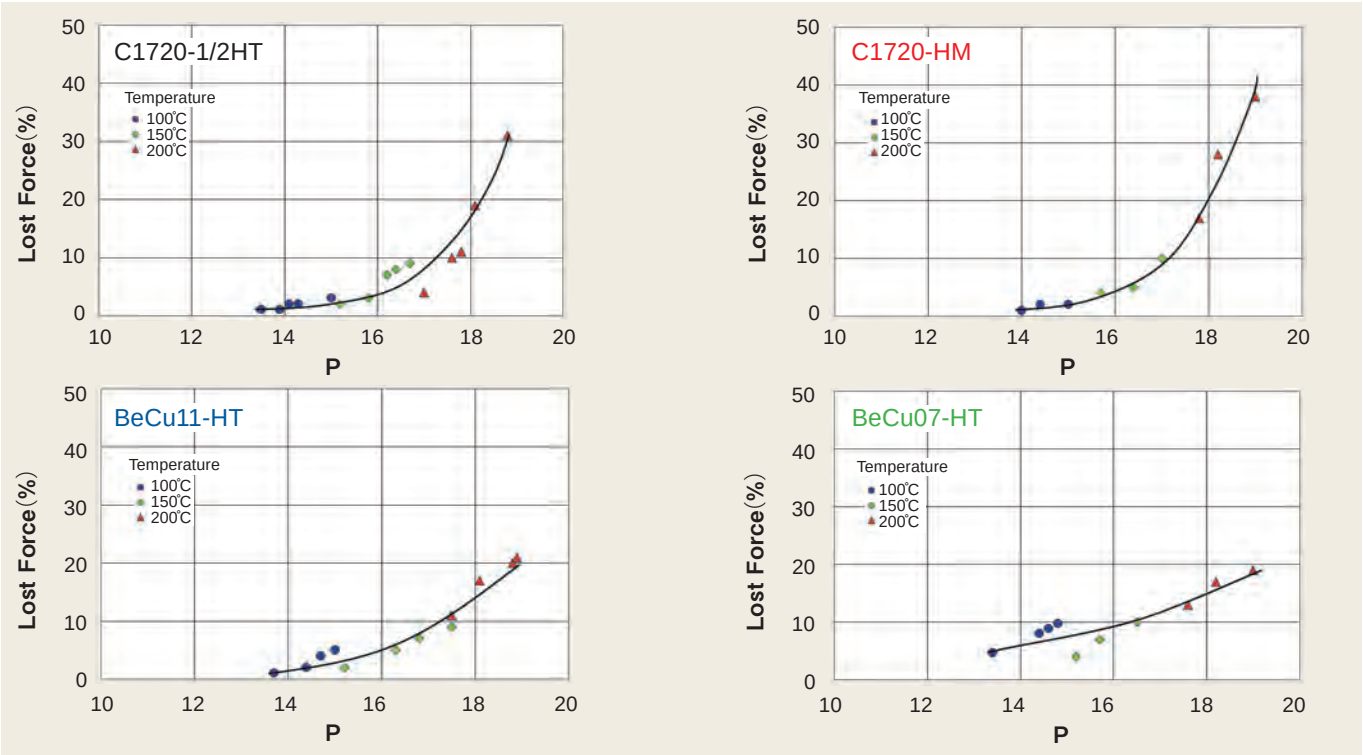


Fig. 5 Relationship between Remaining Stress and Larson-Miller Parameter "P"

Potential of Copper Beryllium

Fatigue Strength

Fatigue strength is important to assure the reliability of contact springs in micro switches or relays for which cyclic motions are required. Fig. 6 shows the fatigue strength of various copper alloys.

Copper beryllium alloy 25 has higher fatigue strength than any other copper alloy, e.g. 8 times longer durability than phosphor bronze, while alloy 11 and 7 exhibit slightly higher fatigue strength than Phosphor Bronze.

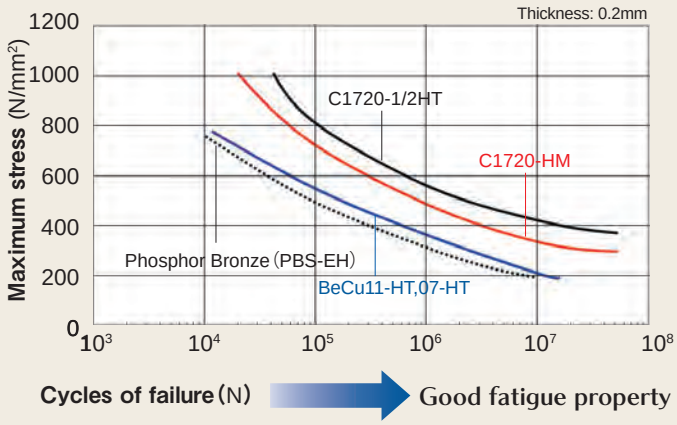


Fig. 6 Fatigue Strength
Copper Beryllium vs. Phosphor Bronze

Note : The test method is based on the Japan Copper and Brass Association technical standard JCBA T308.

Electrical Conductivity and Heat Generation

High current (up to 30A) passes through the contact springs in automotive components and relays. Because of its high electrical conductivity, copper beryllium can minimize heat generation caused by resistivity of a contact spring, even if it carries a high current.

Fig. 7 shows the rise in temperature when a current of 20A is passed through test pieces in copper beryllium or phosphor bronze (test piece in 0.2mm x 10mm x 75mm).

After 500 seconds the temperature rises up to 80/90℃ in alloy 25, approx. 70℃ for alloy 7 and approx. 60℃ for alloy 11, while it reaches more than 120℃ in phosphor bronze. Since the internal heat generated by the resistivity of a given material may cause stress relaxation in service, the selection of high conductive material is essential for switches or relays subject to high amperage load.

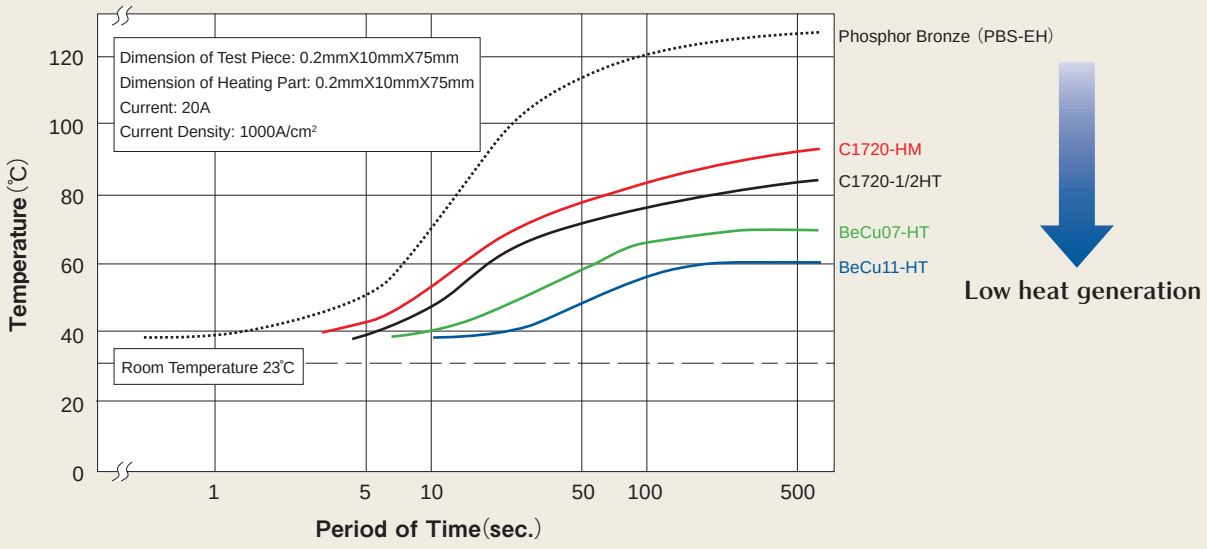


Fig. 7 Rise in Temperature by Resistance Heating,
Copper Beryllium vs. Phosphor Bronze

Corrosion Resistance

In general, copper and its alloys have good corrosion resistance. Among various copper alloys, copper beryllium has excellent corrosion resistance and a low sensitivity to stress corrosion which can be serious for brass and nickel silver. Also copper beryllium has a better corrosion resistance against seawater than aluminum bronze or copper nickel.Therefore, copper beryllium is an ideal material when corrosion resistance and mechanical strength are required at the same time. A dense oxide film is formed on the surface of copper beryllium by age hardening and acts as protective coating. Thus, copper beryllium also shows good resistance against discoloration at a high temperature.

Fig. 8 shows the magnitude of corrosion by salt water spray in comparison with other copper alloys. Phosphor bronze and copper titanium corrosion will advance at a much more rapid pace than copper beryllium.

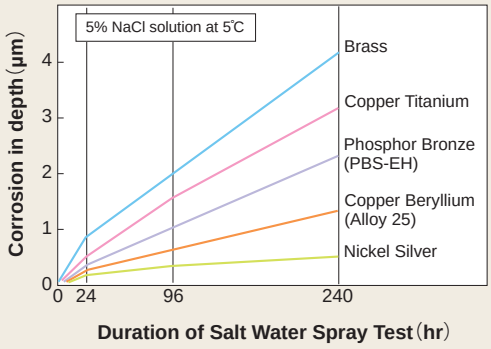


Fig. 8 Corrosion of Copper Alloys (Salt Water Spray)

Aging Conditions and Aging Furnace

The increase in the mechanical properties of copper beryllium can be controlled through the heat treatment conditions and the cold rolling reduction rates, i.e. temper. This is shown by age hardening curves in Fig. 9 and 10.

● Heat Treatment Conditions

Standard heat treatment conditions for copper beryllium alloy 25 age hardenable material are temperature of 315℃ and retention time of 2 to 3 hours. The retention time must be counted after the material has reached 315℃. When the volume or weight of parts to be heat-treated in a furnace is relatively large, it is important to ensure that the temperature of the parts is kept at 315℃ for 2 to 3 hours bydirectly attached thermocouple.

Although the required time to heat up the temperature to 315℃ or to cool down to room temperature gives little influence on the properties in case of standard heat treatment conditions, it must be checked carefully when other conditions are applied, e.g. for shorter time or at higher temperature.

● Atmosphere of Furnace

Heat treatment of copper beryllium is usually performed in an inert gas atmosphere, such as nitrogen, carbon dioxide or argon. It is not recommended to use air as the atmosphere of the heat treatment for electric components, because an intensive black oxide film will be formed on the surface. In order to keep the uniformity of the temperature in a furnace, it is better to circulate the atmosphere.

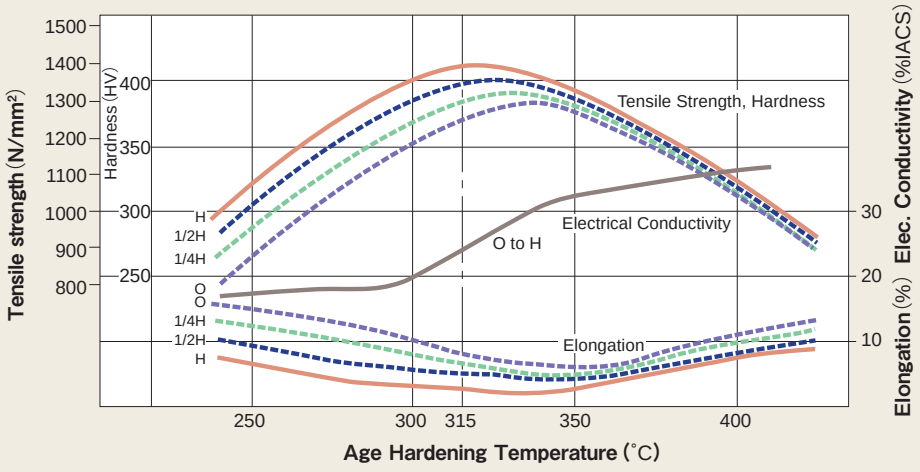


Fig. 9 Properties of Alloy 25 after Age Hardening at different Temperatures (Retention Time: 2 hours)

Age Hardening Temperature (°C)

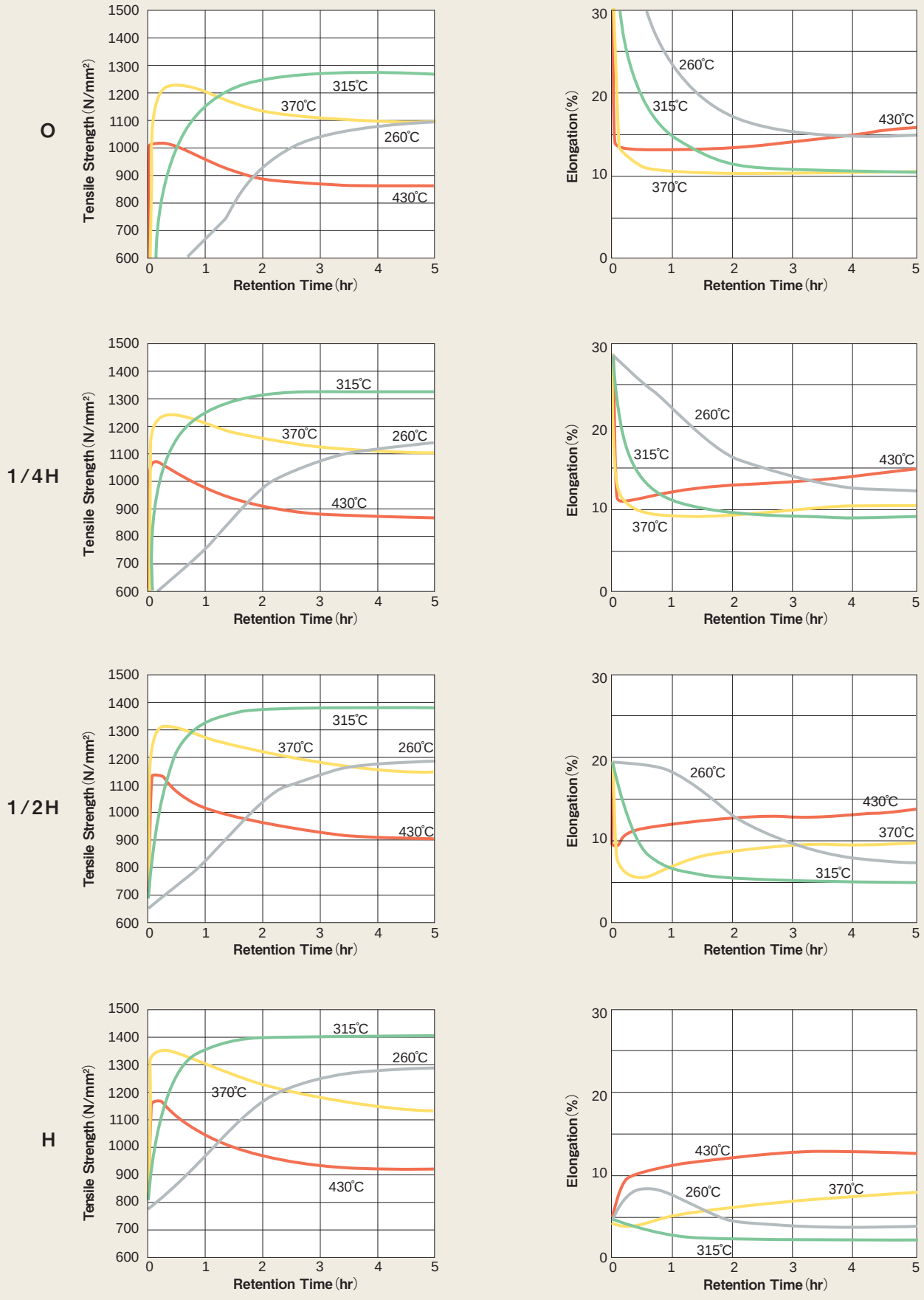


Fig. 10 Age Hardening Curve of Alloy 25

Shrinkage (Alloy 25)

The mechanical properties of copper beryllium alloy 25 are drastically increased by age hardening, because beryllium atoms, which were dispersed in copper as a solid solution, are precipitated through various process during age hardening. This results in a shrinkage of approx. 0.15% in length. This is the reason age hardening of stamped parts may cause slight deformation.

The shrinkage varies slightly depending on the temperature of age hardening and the cold reduction prior to stamping. The following methods have proven effective in minimizing distortion.

(1) to select higher temper within the limitation of bending formability, e.g. 1/2H rather than 1/4H, H rather than 1/2H.

(2) to fix the parts in jigs or to place them in copper powder and apply pressure, if the shape of the parts is complicated.

(3) to apply lower age hardening temperature, e.g. from 315˚C to 280˚C. |n this case the mechanical strength will be lower to some extent.

(4) Parts formed from mill hardened material can be further heat treated after stamping with very little distortion.

Surface Treatment

● Acid Cleaning

Copper beryllium alloys tend to form oxide film on the surface during heattreatment.

The oxide film must be removed when further processing such as plating and soldering is necessary. Typical cleaning methods are as follows:

for loose parts, dip them into a 20% solution of sulfuric acid heated up between 50˚C to 90˚C.The oxide film will be removed in a few minutes. When time allows, the parts can be immersed in the solution at room temperature over night. Since oxide film generated by burnt oil or grease cannot be removed by acid cleaning, degreasing before age hardening is required.

● Degreasing

Any residual oil or grease on the surface of copper beryllium may cause the discoloration on the surface or may give an adverse effect on down stream processes such as heat treatment, plating, soldering and welding. When stamping oil is used, thorough degreasing is required after stamping. If the stamping oil contains high chlorine or sulfur, the method of degreasing should be carefully determined, or the use of such oil should be avoided.

● Preventive treatment against discoloration

Benzotriazol ($C_6H_4N_2$-NH) is generally used for preventing the discoloration of copper alloys caused by the air. It forms cupric benzotriazol $(C_6H_4N_3)_2Cu$ on the surface of copper alloys, which is insoluble in water or other solvents. It will not cause any adverse effect on normal pretreatment for plating or age hardening, because it will be sublimated at 100˚C.

Proper Use of Copper Beryllium

Environmental Reference

【 Laws and regulations 】

● Regulations on Chemical Substances

As of September 2007 several regulations have been in force e.g. EU Directives RoHS (since Jul.1, 2007) and ELV (since Jul. 1, 2003) as well as J-MOSS (since Jul. 1, 2006) and "Chinese RoHS" (since Mar. 1, 2007). However, none of them regulate the use of copper beryllium.

Our copper beryllium fully complies with those regulations. We will send the analysis data (ICP Data) which certify the content of regulated substances in our copper beryllium upon request.

【 Handling of copper beryllium 】

● Effect on Human body

Since copper beryllium is stable in solid state, it does not cause any particular effect on the human body. In most cases, copper beryllium will be stamped, heat-treated and plated. For these processes, copper beryllium can be treated in the same way as other copper alloys.

● Effect on Environment

NGK has established a special division to work on concerns about handling and recycling of copper beryllium. If you have any question aboutthe environmental issues or recycle of stamping scrap of copper beryllium, you may reach us at the below contact information provided.

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