CuMg0,2

UNS:C18661
EN:CW127C

Manufactures list:
La Farga (http://www.lfl.es) - CuMg0,2

Wires made of the copper-magnesium CuMg0,2 alloy belong to low-alloyed copper materials which are characterized by very good electrical conductivity as well as by excellent mechanical properties. [Ref: 82]
Compared to copper, CuMg0,2 in cold work-hardened condition is characterized by significant higher strength, essentially better softening performance and outstanding behavior under reversed bending stresses. CuMg0,2 offers good cold forming performance and fine drawability. [Ref: 82]

The reduction of the electrical conductivity of copper caused by magnesium is relatively small. The strengthening effect, however, is significant. In comparison to CuMg0,1, CuMg0,3 features higher strength with little lower electrical conductivity. Therefore, it is very suitable for contact wire and catenary cables for high-speed trains. [Ref: 89]

Magnesium is one of those elements reducing the electrical conductivity of copper only insignificantly. However, its strengthening effect is considerable. Within the copper - magnesium - alloy - family, CuMg0,1 has the highest electrical conductivity. Therefore, it is very suitable for the connection of electric components as well as for suspended cables. [Ref: 86]

Copper-magnesium is a solid solution alloy providing high strength with nominal reduction in conductivity relative to copper. CuMg0,1 combines high electrical conductivity with good tensile strength, excellent solderability and plate ability. Applications include connectors, semiconductor, pins,stranded wire, contact parts for the lighting industry, contact elements, telecommuncation cables, (car) wire harnesses, flat wire, special screws, pressed parts, rivets, catenary trolley cables and conductors. [Ref: 93, 664]

Basic properties

Basic properties	Value	Comments	Literature
Density [g/cm^3]	8,89-8,9		[Ref: 82, 93, 665, 666]
Specific heat capacity [J/(kg*K)]	No data		
Temperature coefficient of electrical resistance (0...100°C) [10^{-3}/K]	3,13-3,2		[Ref: 99, 666]
Electrical conductivity [T=20°C, (% IACS)]	62-85		[Ref: 82, 97, 86, 90, 94, 89, 93, 88, 665, 666]
Thermal conductivity [W/(m*K)]	310		[Ref: 82]
Thermal expansion coefficient 20...300°C [10^{-6}/K]	17		[Ref: 82, 93, 97]

Applications

Main applications

Due to its physical properties this wire material is predestined to be used in automotive power systems, e.g. in terms of miniaturized cross sections of wiring harnesses. SF02 does not contain any cadmium and is characterized by high purity of its alloy components. As many other copper alloys produced by Sundwiger Messingwerk, SF02 is one of the "green materials" and can be recycled easily. [Ref: 82]
Typical Applications - Conductive and connecting wire - Wiring harnesses - Semiconductor pins - Telecommunications cable - Telecommunications cord [Ref: 82] Electrical: Terminal Connectors, Conductors, Terminals, Contacts, Wire, Catenary, Trolley Wire.

Kinds of semi-finished products/final products

Availability: [Ref: 666]

Coating: Bare, Silver, Nickel, Tin, Gold

Temper: Soft or hard

Single end conductors, Stranded conductors, Bunched conductors, Concentric lay conductors

Single end size ≥ 0.025 mm (AWG 50), Other diameters or special constructions are available

Special applications:

-Automotive industry

The emphasis is more and more shifting towards environmental protection and husbanding of resources, with the focus revolving around the minimization of weight and consumption accompanied by heightened standards of safety and comfort. The growing use of electronic assistance systems constitutes a major step in this direction, which entails an increasing demand for signal cables. At the same time, the space accorded to cable harnesses is declining because of optimized safety systems. Signal cables made from LEONI Histral® H77 have the potential to render an important contribution to overcoming this predicament. [Ref: 666]

-Data cables / Signal cables

Its small alloy portion reduces the resistance value of LEONI Histral® H77 no more than a little, as compared with pure copper. Thus, the very good electrical conductivity of the material remains unaffected whilst its excellent mechanical strength persists. This makes it a perfect fit for data cables and signal cables featuring very low diameters and cross-sections, but also a sufficient tensile strength. [Ref: 666]

Copper Magnesium has the highest tensile strength when compared to other alloys, making it the perfect alloy for contact wire in high speed lines with speeds well above 300 km/h. Together with the CuCd, it is the preferred alloy for the messenger cables, having the appropriate strength to carry the entire catenary system. [Ref: 663]

Chemical composition

Chemical composition	Value	Comments
Cu [wt.%]	99,59-99,9	Calculated
Mg [wt.%]	0,1-0,3	
P [wt.%]	0,01	max.
Others [wt.%]	0-0,1	max.
[Ref: 571]		

Chemical composition of SF02 Copper-Magnesium alloy from Diehl [Ref: 82]

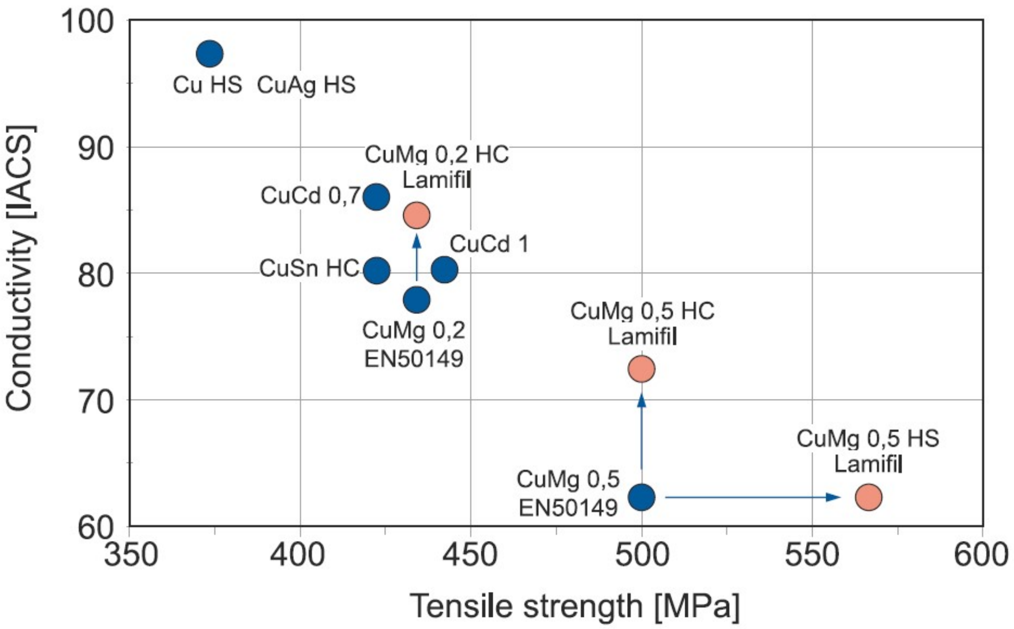
Chemical composition, wt.%			
Mg	P	Other	Cu
0,2	≤ 0,01	≤ 0,1	rest

Mechanical properties

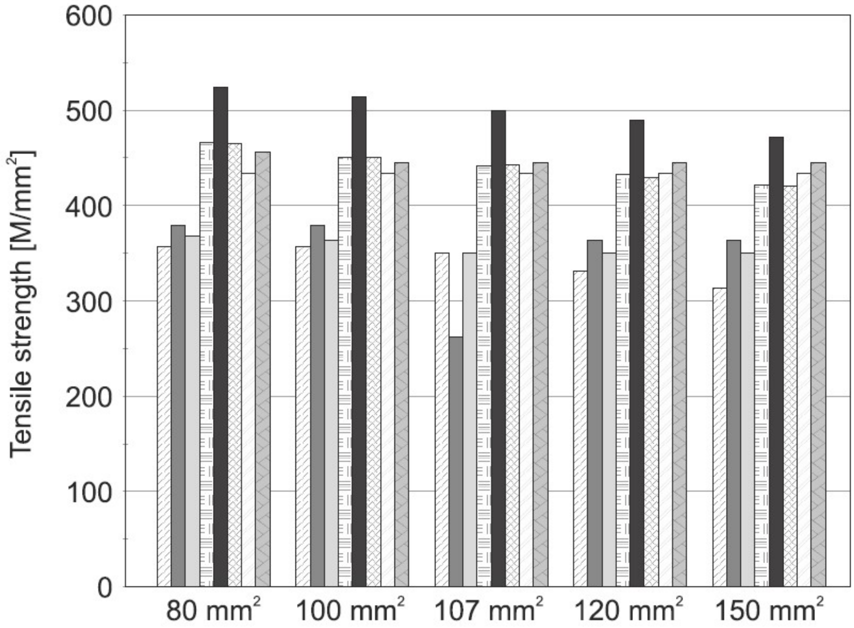
Mechanical properties	Value	Comments	Literature
UTS [MPa]	230-800	soft - hard	[Ref: 89, 86, 88, 665, 666]
YS [MPa]	370	min.	[Ref: 97, 85]
Elongation [%]	1-30	Depends on temper	[Ref: 97, 85, 665, 666]
Hardness	No data		
Young's modulus [GPa]	120-125	cold formed	[Ref: 93, 97]
Kirchhoff's modulus [GPa]	No data		
Poisson ratio	No data		

Mechanical properties of CuMg0,3 [Ref: 89]

Nominal diameter, mm	Temper	Tensile strength, MPa
1,2-5,0	soft	360
1,0	hard	670
1,3	hard	640
1,5	hard	620
2,0	hard	580
2,5	hard	560
3,0	hard	540
3,5	hard	520
4,0	hard	510
5,0	hard	500

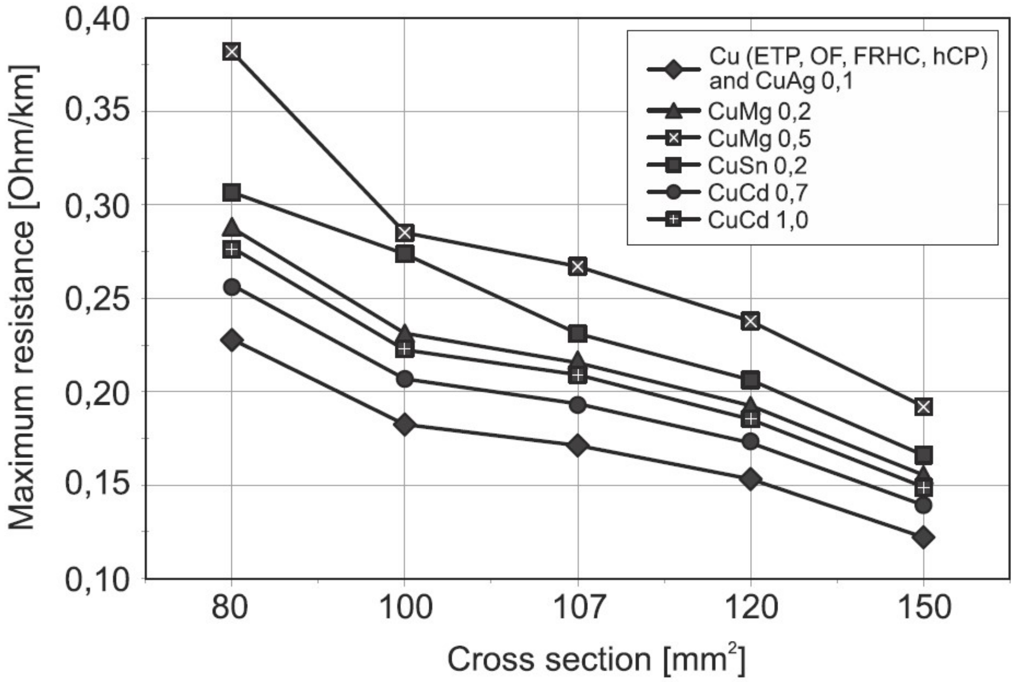


Comparison of the electrical and mechanical characteristics of some of copper alloys designed for trolley wires [Ref: 663]

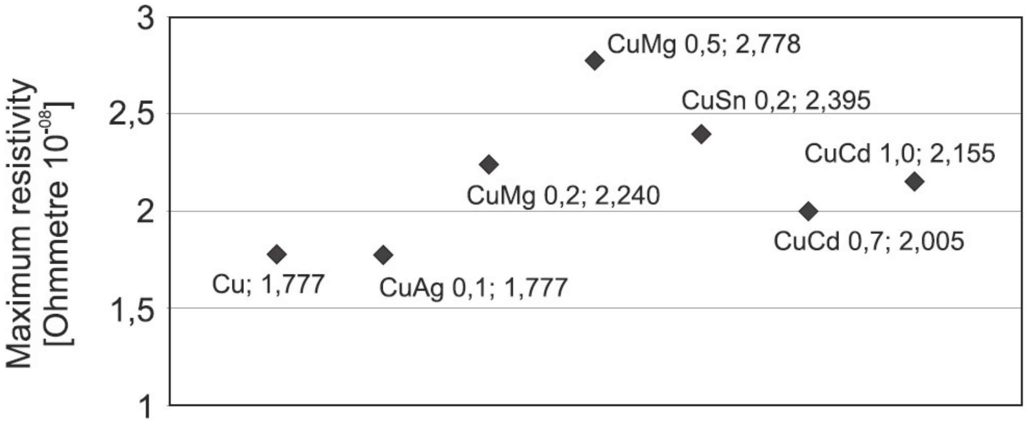


Cu	355	355	350	330	310
HighSt.Cu&CuAg	375	375	260	360	360
CuAg 0,1	365	360	350	350	350
CuMg 0,2	460	450	440	430	420
CuMg 0,5	520	510	500	490	470
CuSn 0,2	460	450	440	430	420
CuCd 0,7	430	430	430	430	430
CuCd 1,0	455	445	445	445	445

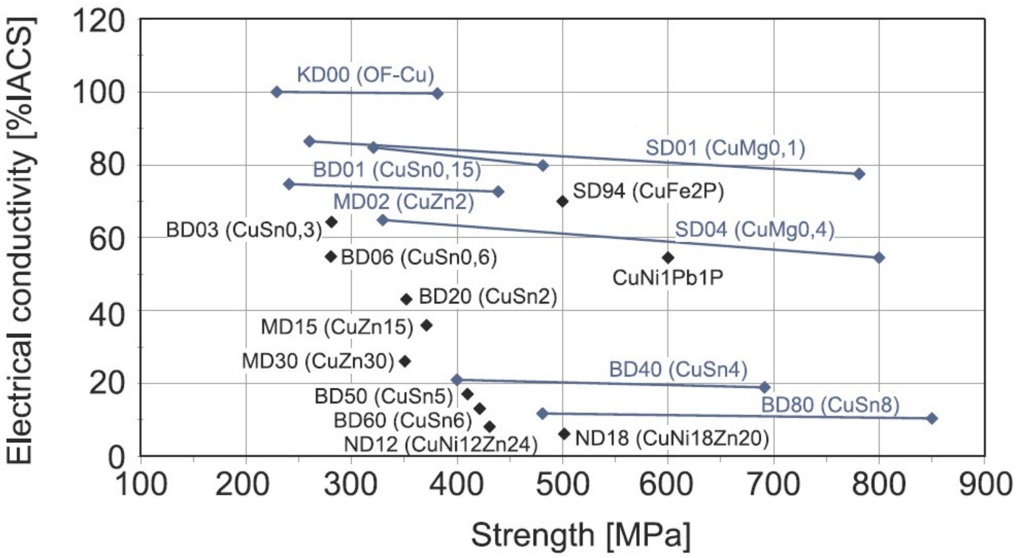
Tensile strength comparison of trolley wires made from copper and copper alloys [Ref: 662]



Maximum resistance comparison of trolley wires made from copper and copper alloys [Ref: 662]



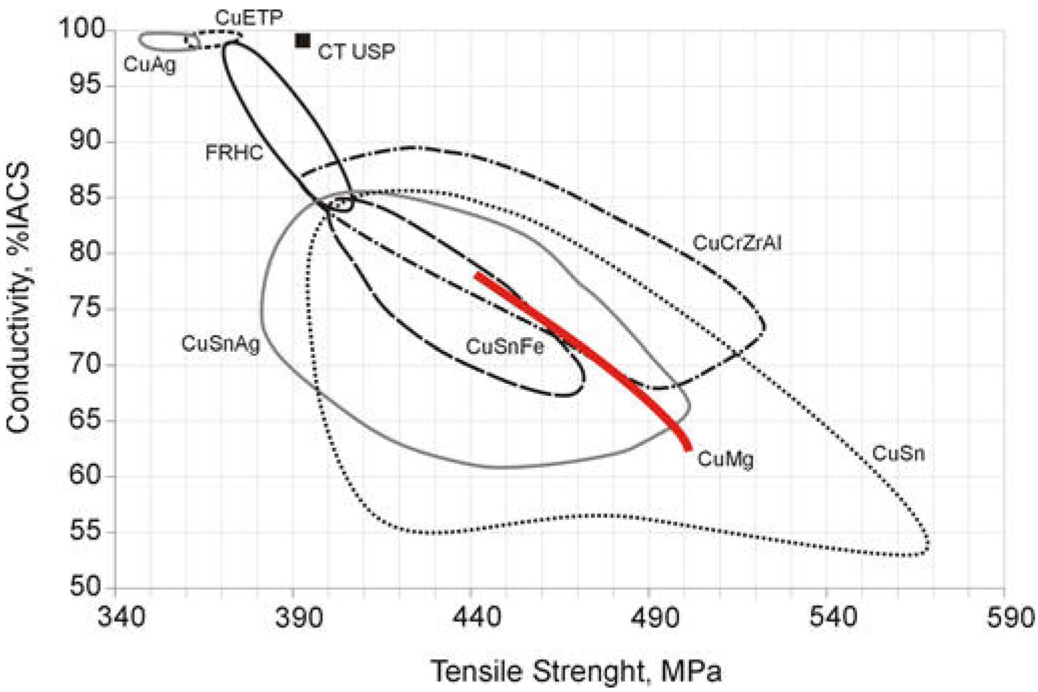
Maximum resistivity comparison of trolley wires made from copper and copper alloys [Ref: 662]



Tensile strength and electrical conductivity of selected copper alloys [Ref: 667]

Comparison of the electrical and mechanical characteristics and heat resistance of trolley wires made from different copper alloys [Ref: 668]

Material	Electrical conductivity, %IACS	Tensile strength, MPa	Elastic limit, MPa	Recrystallization temperature, °C
CuETP	99,5	370	356	220
CuAg0,1	98,7	370	360	340
EVELEC	87,2	405	374	380
CuMg0,2	77,8	440	432	410
CuMg0,5	60,5	500	440	420



Electrical conductivity as a function of tensile strength. Application of copper based alloys for trolley wire [Ref: 92]

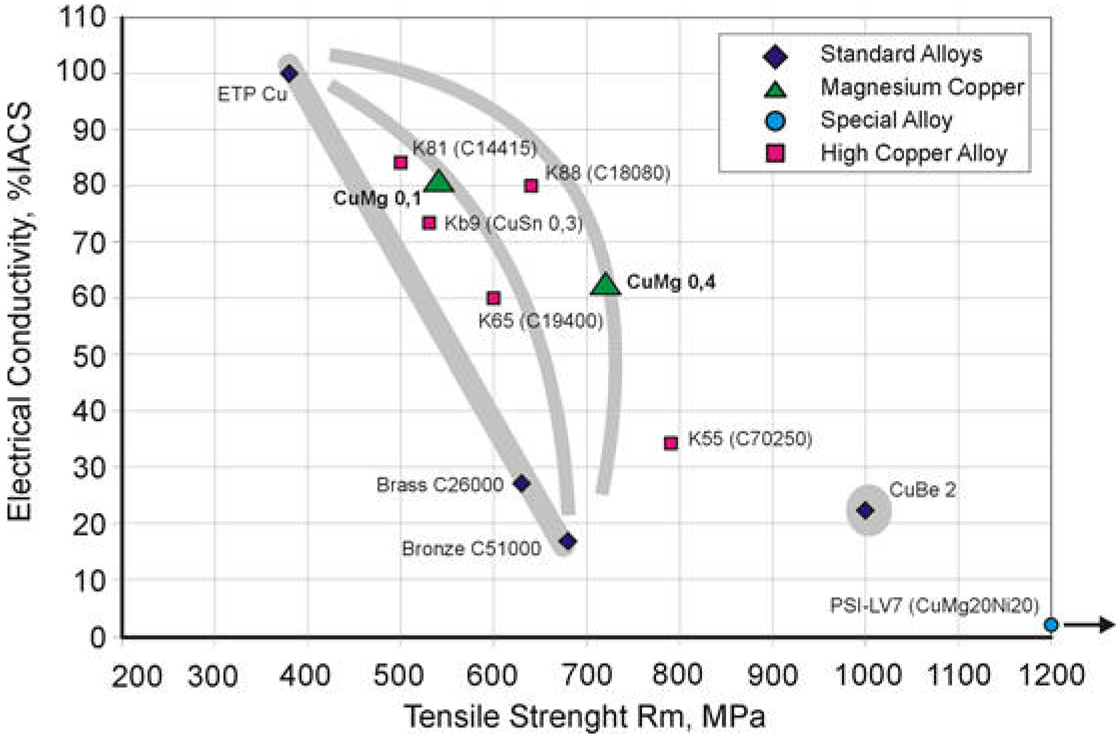
Mechanical properties of CuMg0,1 [Ref: 86]

Nominal diameter, mm	Temper	Tensile strength, MPa
1,2-5,0	soft	290
1,0	hard	500
1,3	hard	480
1,5	hard	470
2,0	hard	465
2,5	hard	420
3,0	hard	415
3,5	hard	405
4,0	hard	390
5,0	hard	380

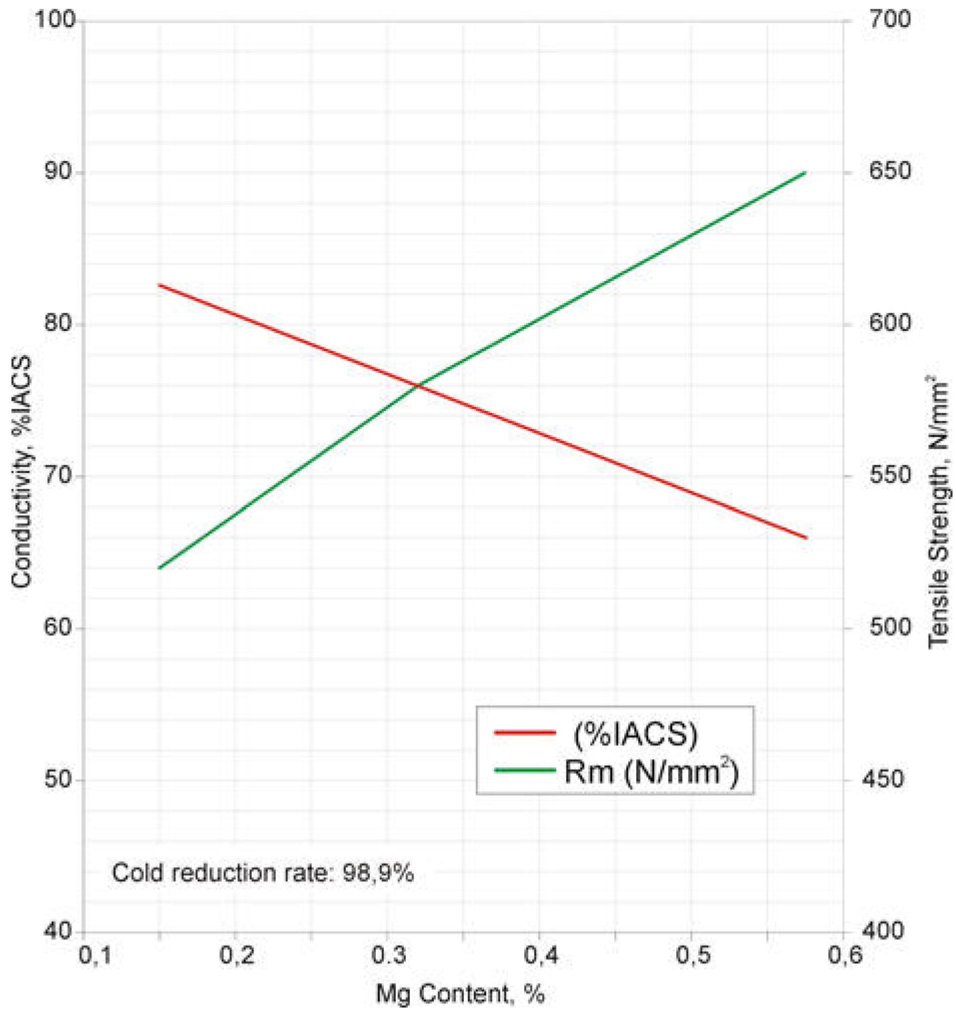
Mechanical and electrical properties of FLCUMGRY cable [Ref: 88]

Cross-section	0,13 mm2
Tensile strength	>770 MPa
Electrical resistance, max.	170 Ω/km
Outer diameter	1,05 m
Approx. cable weight	2 kg/km

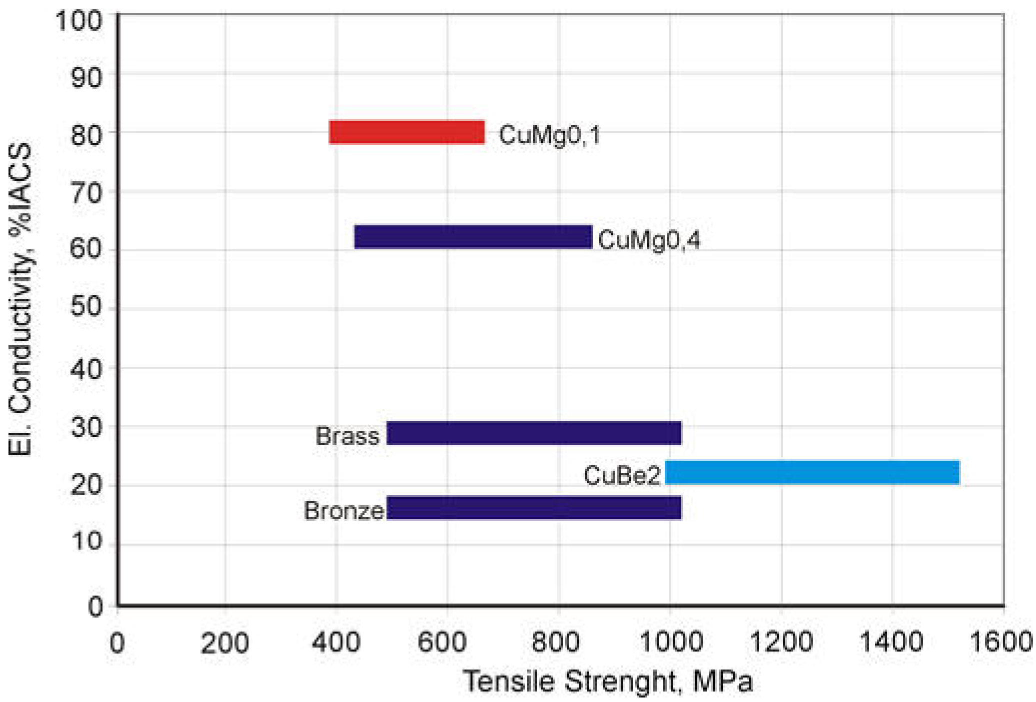
The tensile strength depends on the degree of cold-forming, and therefore, also on the diameter.



Mechanical and electrical properties of different copper alloys [Ref: 90]



Change of CuMg alloy conductivity and strength along with the Mg content [Ref: 94]



Properties of square wire made from different copper alloys, dimension: 0,63x0,63mm [Ref: 84]

Mechanical properties round & square wires as drawn, CuMg0,1 [Ref: 93]

Temper	Tensile strength, MPa
Annealed	241-317
½ hard	379-482
Hard	517-620
Spring	Min. 620

Mechanical properties of CuMg0,1 and CuMg0,3 alloys (reference values, not standardized) [Ref: 94]

Highest tensile strength for diameter, MPa	CuMg0,1	CuMg0,3
Soft annealed	290	360
5	380	500
3,5	405	520
3,0	415	540
2,5	420	560
2,0	465	580
1,5	470	620
1,3	480	640

Mechanical properties of CuMg0,1, CuMg0,2 and CuMg0,3 alloys [Ref: 95]

Tensile strength, MPa	CuMg0,1	CuMg0,2	CuMg0,3
annealed	220-290	230-300	250-320
Hard	300-400	360-460	400-500
Spring hard	400-500	460-560	500-600
Super spring hard	500-700	560-800	600-820

Mechanical and electrical properties of CuMg0,2 [Ref: 97]

Cross-section mm2	80	100	107	120	150
Min. tensile strength, MPa	460	450	440	430	420
Min. breaking load, KN	35,7	43,6	45,7	50,1	61,1
Elongation at break A200, %	3-10	3-10	3-10	3-10	3-10
Yield strength, MPa	>370	>370	>370	>370	>370
Electrical resistance, Ω/km	≤0,289	≤0,231	≤0,216	≤0,192	≤0,154

Trolley wires properties [Ref: 84]

Specifications	Trolley wires (according EN 50149), cross-sectional area, mm2				
	80	100	107	120	150
UTS, MPa	460	450	440	430	420
Breaking load, kN	35,7	43,6	45,7	50,1	61,1
Elongation, A200, %	3÷10	3÷10	3÷10	3÷10	3÷10
Young Modulus E, GPa	120	120	120	120	120
Yield stress, Rp0,2, MPa	>370	>370	>370	>370	>370
Half hard point, °C	≥385	≥385	≥385	≥385	≥385
Electrical conductivity, 20°C	≥44,6	≥44,6	≥44,6	≥44,6	≥44,6
Electrical coductivity, % IACS	≥77	≥77	≥77	≥77	≥77
Resistivity, 10-8 Ohm*m	≤2,240	≤2,240	≤2,240	≤2,240	≤2,240
Electric resistance, Ohm/km	≤0,289	≤0,231	≤0,216	≤0,192	≤0,154
Creep resistance, ‰ Temperature 150 °C, preload 100N per mm2, time 1000h	0,1	0,1	0,1	0,1	0,1
Thermal coefficient of electrical resistance, 10-3/K	1,85	1,85	1,85	1,85	1,85
Thermal expansion coefficient 20 … 300 °C, 10-5/K	1,7	1,7	1,7	1,7	1,7
Density, 103 kg/m3	8,89	8,89	8,89	8,89	8,89

Technical data of CuMg0,2 (VALCOND) [Ref: 85]

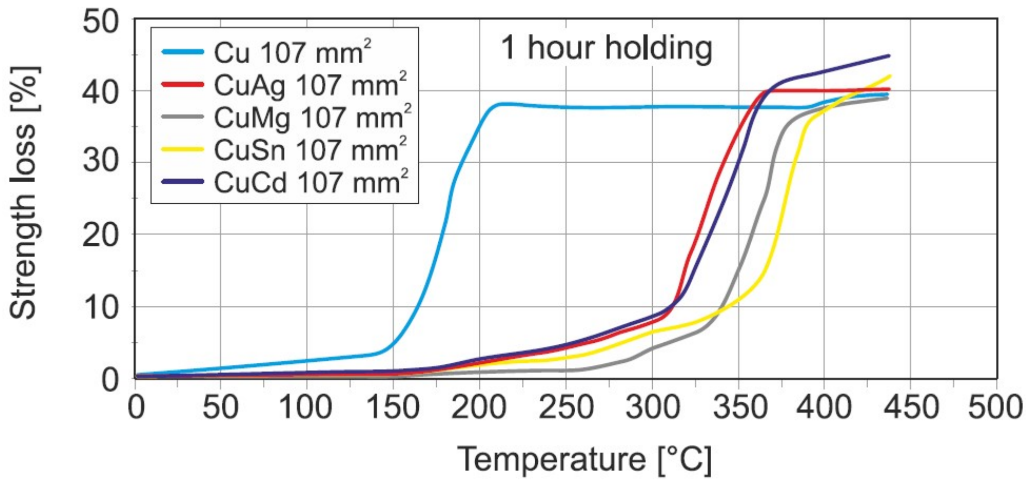
		80		100		107		120		150	
		VALCOND	standard	VALCOND	standard	VALCOND	standard	VALCOND	standard	VALCOND	standard
Min. tensile strength 3)	MPa	460	460	450	450	450	440	450	430	430	420
Min. breaking load 1)	kN	36,0	35,7	44,1	43,6	43,6	45,7	52,9	50,1	63,2	61,1
Percentage elongation after fracture A200	%	3÷10	3÷10	3÷10	3÷10	3÷10	3÷10	3÷10	3÷10	3÷10	3÷10
Modulus of elasticity	GPa	120	120	120	120	120	120	120	120	120	120
0,2% proof strength Rp0,2	MPa	>370	>370	>370	>370	>370	>370	>370	>370	>370	>370
Half-Hard point	°C	>370	>385	>370	>385	>385	>385	>370	>385	>370	>385
Electrical conductivity at 20°C	MS/m	≥46,4	≥44,6	≥46,4	≥44,6	≥44,6	≥44,6	≥46,4	≥44,6	≥46,4	≥44,6
Electrical conductivity	%IACS	≥80	≥77	≥80	≥77	≥77	≥77	≥80	≥77	≥80	≥77
Specific electrical resistance at 20°C	10-8 Ωm	≤2,155	≤2,240	≤2,155	≤2,240	≤2,240	≤2,240	≤2,155	≤2,240	≤2,155	≤2,240
Electrical resistance 1)	Ω/km	≤0,275	≤0,389	≤0,22	≤0,231	≤0,231	≤0,216	≤0,183	≤0,192	≤0,147	≤0,154
Creepage elongation 2)	‰	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
Temperature coefficient of electrical resistance 5)	10-3/K	3,1	1,85	3,1	1,85	1,85	1,85	3,1	3,1	3,1	1,85

Linear coefficient of thermal expansion	10-5/K	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,7
Specific mass 4)	103 kg/m3	8,89	8,89	8,89	8,89	8,89	8,89	8,89	8,89	8,89	8,89
1) Calculation based on the minimum cross section of 98% (EN 50149: 97%) 2) Temperature 150C; applied load 100N pro mm2; time 1000h 3) Different tensile strength on request 4) According to EN 50149 5) Standard according to the nominal value of EN 50149, Valcond based on nkt-investigation											

Exploitation properties

Heat resistance

Mechanical and electrical properties vs temperatures



Strength properties of different Cu alloys (Cu-Mg alloy included) designed for trolley wires as a function of heating temperature for 1h heating time [Ref: 663]

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

NO DATA AVAILABLE

Half- softening temperature

NO DATA AVAILABLE

Corrosion resistance

Hydrogen embrittlement resistance

CuMg0,1-CuMg0,3 are resistant to hydrogen embrittlement [Ref: 83]

Other kind of corrosion elements

Type of corrosion	Suitability	Literature

Atmospheric	CuMg has a good resistance in in natural and industrial atmosphere	[Ref: 83]
Marine environment	CuMg has a good resistance in maritime air.	
Stress crack	Practically resistant against stress corrosion cracking	
Hydrogen embrittlement	Resistant	
Electrolytic	no data	-
Other - oxidising acids	Not resistant	[Ref: 83]

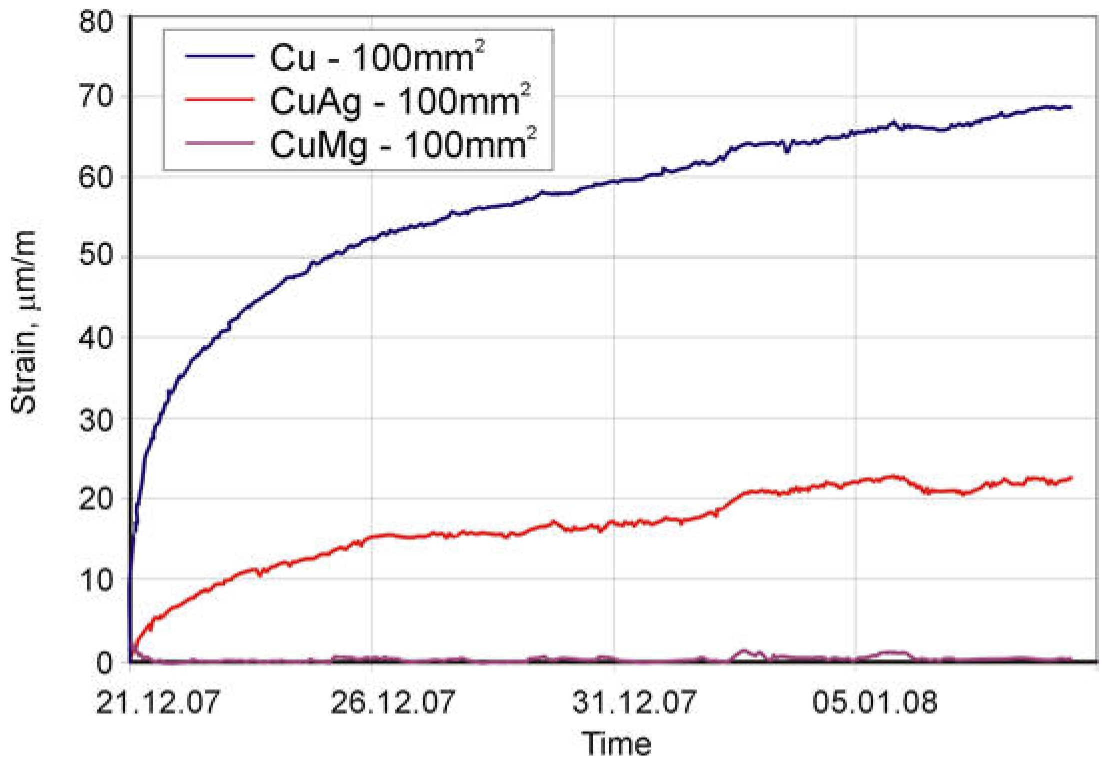
Resistant to atmospheric corrosion: formation of the a greenish protective patina due to the formation of copper basic salts (such sulphates, chlorides in marine environment, nitrates and carbonates). Industrial and drinking water, aqueous and alkaline solutions (not oxidizing), pure water vapour (steam), non-oxidizing acids (without oxygen in solution) and salts, neutral saline solutions. Not resistant to solutions containing cyanides, ammonia or halogens, hydrous ammonia and halogenated gases, hydrogen sulphide, seawater [Ref: 83].

Rheological resistance

Stress relaxation

NO DATA AVAILABLE

Creep



Creeping curves for trolley wires (profile AC, according EN 50149) Progress of additional strain at RT (18°C) Load: F=11,25 kN [Ref: 97]

Wear resistance

Friction resistance

NO DATA AVAILABLE

Fatigue resistance

Fatigue cracking

NO DATA AVAILABLE

Impact strength

NO DATA AVAILABLE

Fabrication properties

NO DATA AVAILABLE

Technological properties

Technological properties	Value	Comments	Literature
Annealling temperature [°C]	400-500		[Ref: 86]
Stress relievieng temperature [°C]	140-180 160-200		[Ref: 86] [Ref: 89]

References:

82. **Copper-Magnesium SF02** - Diehl Metall

83. **CuMg C18665 STOL 78** - KME

84. **Precipitation hardened high copper alloy Precipitation alloys for connector pins made of wire** - R. Zauter and D.V. Kudashov , Wieland-Werke AG, D- 89070 Ulm.

85. **Data sheet - Innovation in railway technology** - NKT Cable

86. **Data sheet - WIRE Alloy SD 01 CuMg0,1** - Diehl Metall

88. **Data sheet - Copper Magnesium – CuMg** - Leoni

89. **Data sheet - SD03-EN** - Diehl Metall

90. **Data sheet - High-performance copper-alloy wire** - Wieland

92. **Comparative study of electrical and mechanical properties of fire-refined and electrolytically refined cold-drawn copper wires** - Monica Martinez, Ana I. Fernandez, Merce Segarra, Helena Xuriguera, Ferran Espiell, Nuria Ferrer, J Mater Sci (2007) 42:7745–7749

93. **Copper-magnesium CMG1** - Fiskalloy.com

94. **Copper Alloys for connector, springs and lead frames** - Jürgen Langer DIEHLMetall

95. **Kupfer-Magnesium-Legierungen** - Diehl Metal

97. **Data sheet - CONTACT WIRE AND STRANDED CONDUCTORS FOR OVERHEAD CATENARY SYSTEMS** - LILJEDAHL BARE WIRE

99. **Corrosion resistance of dilute CuMg alloys at elevated temperature, Corrosion Science** - G.J. Liu, S.S. Jia, S.H. Hong, J.W. Lim, Y.F. Zhu, , , K. Mimura, M. Isshiki, , Volume 51, Issue 3, March 2009, Pages 463–468

571. **EN 50149:2012, Railway applications - Fixed installations - Electric traction - Copper and copper alloy grooved contact wires** -

662. **THE USE OF COPPER AND COPPER ALLOYS IN RAILWAY SYSTEMS** - A.Gamze ONUK, Sarkuysan Elektrolitik Bakır San. ve Tic. A.Ş., İstanbul, Türkiye, Uluslar arası Raylı Sistemler Mühendisliği Sempozyumu (ISERSE'13), 9-11 Ekim 2013, Karabük, Türkiye

663. **Catenary Wires, SOLUTIONS FOR URBAN TRANSPORT SYSTEMS AND HIGH - SPEED RAIL NETWORKS** - Lamifil

664. **Overview of Copper Alloys for Wire** - Diehl

665. **Copper magnesium: SD01 / SD02 / SD03 / SD04 / SD05** - Diehl Metall

666. **Data Sheet - Histral® H77, Copper based alloy, CuMg0.2** - LEONI

667. **Tensile strength and electrical conductivity of selected copper alloys** - Diehl Metall

668. **High performance copper alloy** - Patent: EP 2505679 B1, La Farga Lacambra,

S.A.U.