European Copper Institute
Copper Alliance

AGH

LTPMN
Laboratorium Technologii Przetwórstwa Metali Nieżelaznych

CuFePMg

UNS:C19700
EN:-

High strength modified copper alloy, best combinations of electrical conductivity, mechanical strength, forming properties and stress relaxation resistance. Magnesium is an important element to form fine dispersoids having a particle diameter of 200 nm or less with P in the copper alloy to thereby improve the strength and the stress relaxation property. These fine Mg-P particles highly contribute to inhibiting the dislocation migration and the grain growth and to the improvement in bendability and stress relaxation property. Forms available: Strips, sheets
CuFePMg fits applications requiring excellent hot and cold workability as well as high strength and conductivity and rheological resistance.

Basic properties

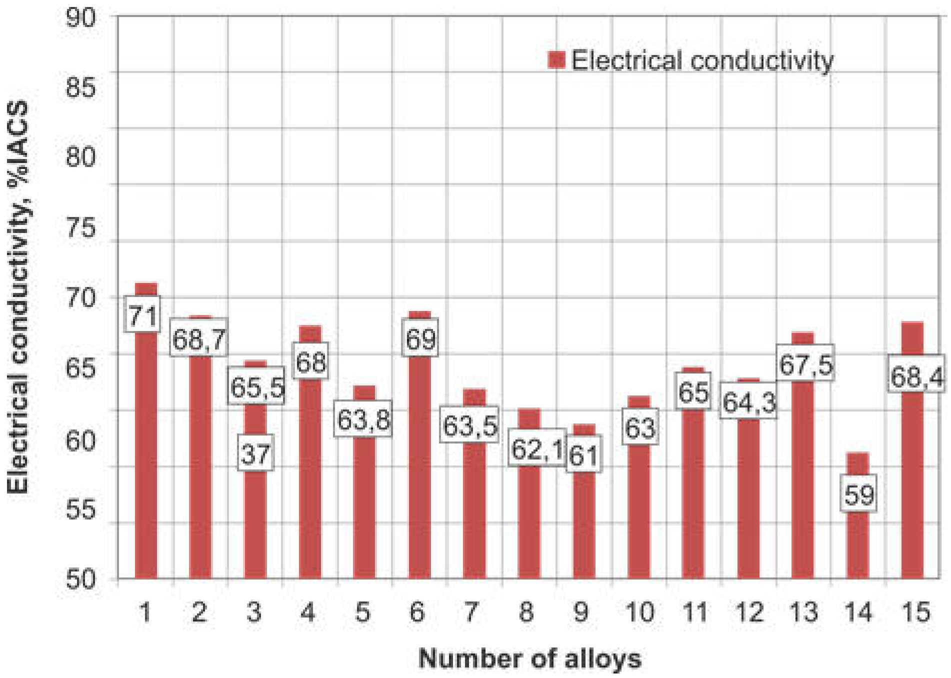
Basic properties	Value	Comments
Density [g/cm^3]	8,89-8,92	
Specific heat capacity [J/(kg*K)]	377 370 394	C19710 C19720 C19750
Temperature coefficient of electrical resistance (0...100°C) [10^{-3}/K]	No data	
Electrical conductivity [T=20°C, (% IACS)]	80	
Thermal conductivity [W/(m*K)]	277	
Thermal expansion coefficient 20...300°C [10^{-6}/K]	17,3	
[Ref: 300, 250, 252, 267, 254, 255, 256, 257]		

Copper alloy having the chemical composition shown in below table was melted in a coreless furnace and an ingot-making was performed by a semi-continuous casting method to yield an ingot 70 mm thick, 200 mm wide and 500 mm long. The surface of each ingot was subjected to facing, followed by heating. There after hot rolling was performed to prepare a sheet 16 mm thick and the resulting sheet was quenched in water from temperature 650°C or higher. Oxidized scale was removed and there after primary cold rolling was performed. The resulting sheet was subject to facing and thereafter to primary annealing and cold rolling. Subsequently, secondary annealing and finish cold rolling were performed and then strain relieving annealing at low temperature was performed to thereby yield alloy sheet about 0.2 mm thick.

The copper alloy sheet sample was processed into a slip-shaped test piece of 10 mm in width and 300 mm in length by milling, an electric resistance was measured with a double bridge resistance meter, and the electrical conductivity was calculated by an average cross-sectional area method.

Electrical conductivity of CuFePMg alloys with different Fe, P and Mg additions [Ref: 301]

No of alloy	Fe	P	Mg	Electrical conductivty	Literature
	wt%			%IACS	
1	0,15	0,10	0,25	71	[Ref: 301]
2	0,91	0,10	0,25	68,7	
3	0,15	0,02	0,25	65,5	
4	0,15	0,36	0,25	68	
5	0,15	0,10	0,10	63,8	
6	0,15	0,10	0,92	69	
7	0,15	0,10	0,25	63,5	
8	0,15	0,10	0,25	62,1	
9	0,15	0,10	0,25	61	
10	0,00	0,10	0,25	63	
11	1,05	0,10	0,25	65	
12	0,15	0,00	0,25	64,3	
13	0,15	0,46	0,25	67,5	
14	0,15	0,10	0,04	59	
15	0,15	0,10	1,10	68,4	



Electrical conductivity of CuFePMg alloys for different Fe, P and Mg content [Ref: 301]

Electrical conductivity of CuFeMgP alloy with Ni, Co, Zn and Sn additions [Ref: 301]

No of alloys	Fe	P	Mg	Ni	Co	Zn	Sn	Electrical conductivity
	Wt %							IACS
1	0,10	1,00	0,25	0,20	0,20	0,10	0,10	61,8
2	0,10	0,10	0,25	0,20	0,20	0,10	0,10	63,5
3	0,10	0,10	0,25	0,20	0,20	0,10	0,10	63,3
4	0,10	0,10	0,25	0,20	0,20	0,10	0,10	57,8
5	0,10	0,10	0,25	0,20	0,20	0,10	0,10	63,8
6	0,10	0,10	0,25	0,20	0,20	0,10	0,10	63,5

Applications

Main applications

Lead frames, Electrical springs, electrical terminals, Connectors, Springs, Clips, Terminals, Sockets. *Literature:* [Ref: 299, 300, 252, 254, 304]

Kinds of semi-finished products/final products

NO DATA AVAILABLE

Chemical composition

Chemical composition	Value	Comments
Cu [wt.%]	98,3-99,08	Calculated
Fe [wt.%]	0,05-0,4	
Mg [wt.%]	0,3-0,6	
Ni [wt.%]	0,1	
P [wt.%]	0,07-0,15	
Pb [wt.%]	0-0,05	
Sn [wt.%]	0,2	
Zn [wt.%]	0,2	
[Ref: 91]		

Chemical composition of CuFePMg (C19720) [Ref: 91]

Chemical composition of CuFePMg (C19750) [Ref: 91]

Chemical composition, weight percentage,												
Ag	**Mg**	**Sn**	**Ni**	**Si**	**Cr**	**Zr**	**Fe**	**P**	**Pb**	**Zn**	**other**	**Cu**
-	0.06-0.2	0.20	0.10	-	-	-	0.05-0.5	0.05-0.15	max. 0,05	0.20	-	rest
-	Nom.0.13	-	-	-	-	-	Nom.0.22	Nom.0.10		-		99.6

Chemical composition, weight percentage,												
Ag	**Mg**	**Sn**	**Ni**	**Si**	**Cr**	**Zr**	**Fe**	**P**	**Pb**	**Zn**	**Co**	**Cu**
-	0.01-0.20	0.05-0.4	0.05	-	-	-	0.35-1.2	0.10-0.40	max. 0,05	0.20	0.05	rest
-	Nom.0.10	Nom.0.22	-	-	-	-	Nom.0.8	Nom.0.25		-		99.6

Mechanical properties

Mechanical properties	Value	Comments	Literature
UTS [MPa]	500-670		
YS [MPa]	450-655		
Elongation [%]	2-15		
Hardness	130	[HV]	
Young's modulus [GPa]	119		
Kirchhoff's modulus [GPa]	No data		
Poisson ratio	0,33		

Mechanical requirements of CuFePMg alloy according ASTM standards (different tempers)

Temper	Tensile strength, MPa	Yield strength 0,2%, MPa	Elongation 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 requirements of CuFePMg according PMX Industries INC

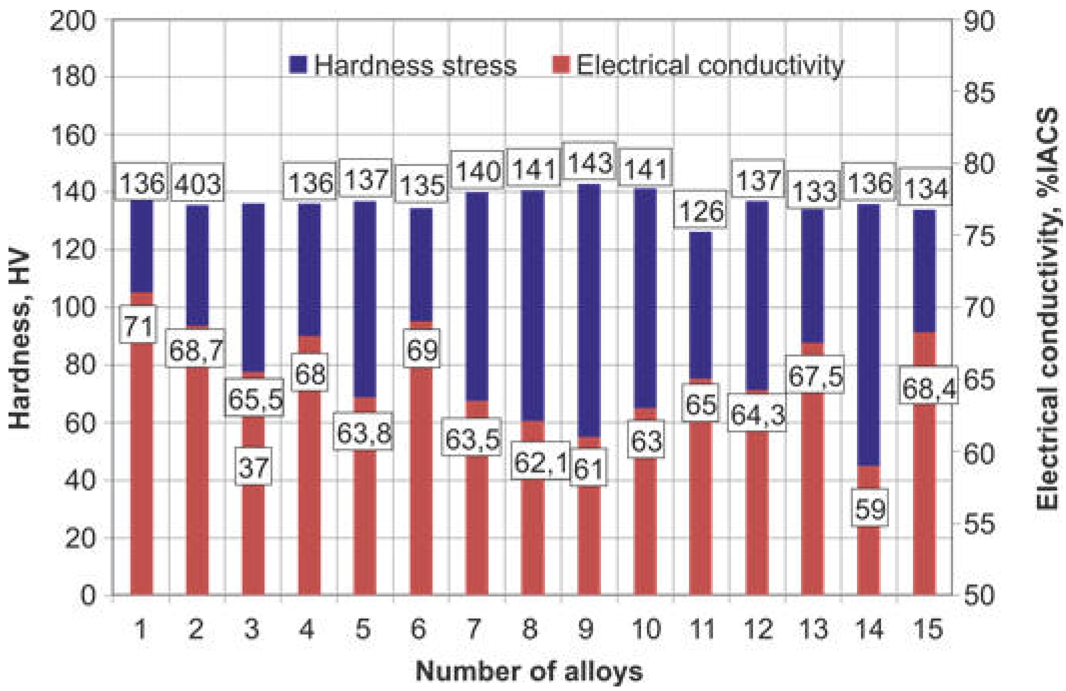
Temper	Tensile strength, MPa		Literature
	min	max	
HO20	365	434	[Ref: 298]
HO40	414	483	
HO60	462	503	
HO80	483	524	

Each copper alloy having the chemical composition shown in below table was melted in a coreless furnace and an ingot-making was performed by a semi-continuous casting method to yield an ingot 70 mm thick, 200 mm wide and 500 mm long. The surface of each ingot was subjected to facing, followed by heating. There after hot rolling was performed to prepare a sheet 16 mm thick and the resulting sheet was quenched in water from temperature 650°C or higher. Oxidized scale was removed and there after primary cold rolling was performed. The resulting sheet was subject to facing and thereafter to primary annealing and cold rolling. Subsequently, secondary annealing and finish cold rolling were performed and then strain relieving annealing at low temperature was performed to thereby yield alloy sheet about 0.2 mm thick.

Mechanical properties of CuFePMg alloys [Ref: 301]

No of alloy	Fe	P	Mg	Proof stress	Hardness
	Wt %			MPa	HV
1	0,15	0,10	0,25	410	136

3	0,91	0,10	0,25	403	135
4	0,15	0,02	0,25	415	37
5	0,15	0,36	0,25	408	136
6	0,15	0,10	0,10	417	137
7	0,15	0,10	0,92	405	135
8	0,15	0,10	0,25	428	140
9	0,15	0,10	0,25	433	141
10	0,15	0,10	0,25	440	143
14	0,00	0,10	0,25	432	141
15	1,05	0,10	0,25	360	126
16	0,15	0,00	0,25	418	137
17	0,15	0,46	0,25	395	133
18	0,15	0,10	0,04	406	136
19	0,15	0,10	1,10	400	134



Hardness and electrical conductivity of CuFePMg alloy [Ref: 301]

Mechanical properties of CuFePMg alloys with Ni, Co, Zn and Sn additions [Ref: 301]

No of alloy	Fe	P	Mg	Ni	Co	Zn	Sn	Proof stress	Hardness
	%wt							MPa	HV
1	0,10	1,00	0,25	0,20	0,20	0,10	0,10	430	140
2	0,10	0,10	0,25	0,20	0,20	0,10	0,10	392	133
3	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	132
4	0,10	0,10	0,25	0,20	0,20	0,10	0,10	421	138
5	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	132
6	0,10	0,10	0,25	0,20	0,20	0,10	0,10	420	138

Exploitation properties

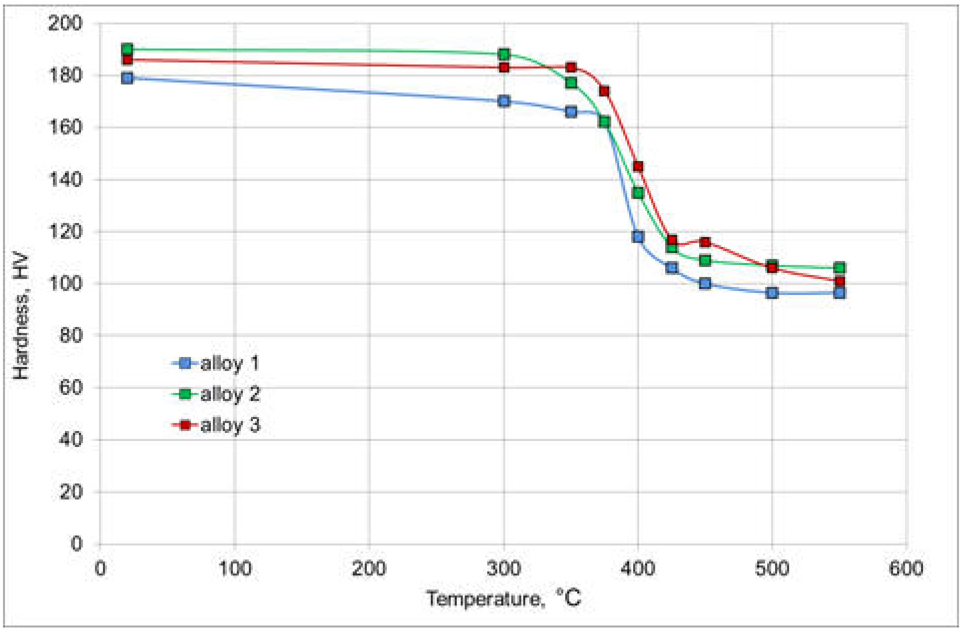
Heat resistance

Mechanical and electrical properties vs temperatures

This example compares the softening resistance of several alloys of this invention as previously described in the aforenoted examples to commercial alloys. Alloys were air melted with charcoal cover and Durville cast to yield twelve pound ingots 15mmx10mmx4,37 mm. The casting temperature was about 1125°C to about 1150°C. The resulting ingots were homogenized at about 850-9000C for 2 hours, then rolled from 4,37 to 1 mm in seven passes with no reheating. To resolutionize the precipitated alloying elements, the strips were returned to the furnace and held at about 850-900°C for 1 hour and then water quenched. The strips were then milled to remove oxide scale and cold rolled to 0,1 mm. The cold rolled strips were then annealed for 2 hours at about 500-5750C. The material was then cold rolled to 0,01 mm, annealed to about 450-500°C for about 2 hours and then measured for electrical conductivity. The material was then finally rolled to 0.025 mm gauge for property measurments. Softening resistance was determined by annealing samples of material at 0.025 mm gauge for 1 hour at various temperatures between 300-550°C followed by measuring the respective Vickers hardness values.

Chemical composition of CuFePMg alloys [Ref: 304]

Type of alloy	Fe	Mg	P	Sn	Ni
	Wt %				
alloy 1	1	0,13	0,32	-	-
alloy 2	0,99	0,13	0,33	0,25	-
alloy3	0,72	0,11	0,31	0,25	0,29



Softening curves of CuFePMg alloys [Ref: 304]

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

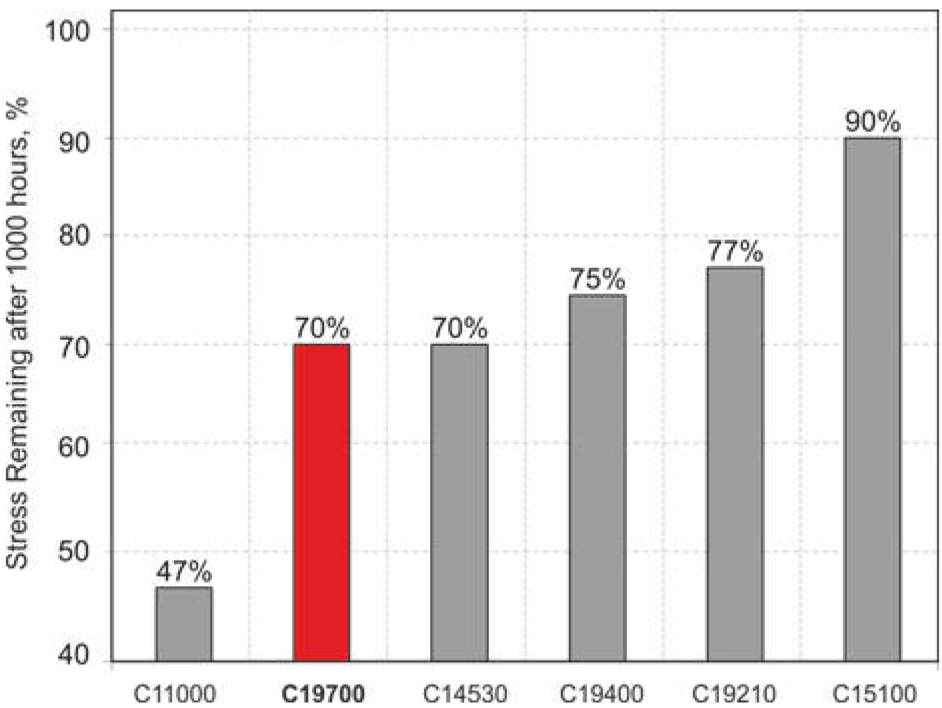
C19700 exhibits good corrosion resistance in natural atmosphere (also sea air) and industrial atmosphere. It is insensitive to stress corrosion cracking.

Type of corrosion	Suitability	Literature
Atmospheric	Good	[Ref: 254]
Marine environment	-	
Stress crack	Good	
Hydrogen embrittlement	-	
Electrolytic	-	

Rheological resistance

Stress relaxation

CuFePMg has a good relaxation stress resistance.

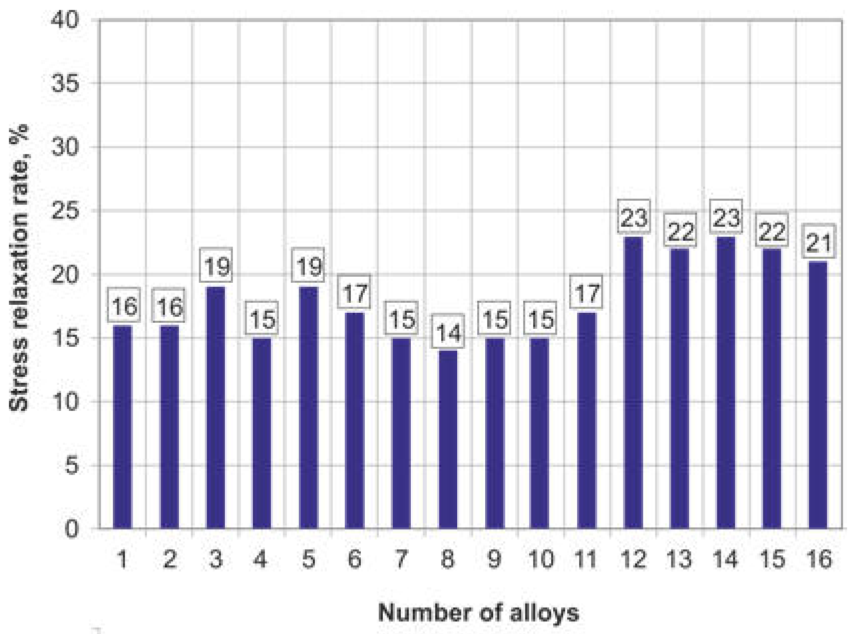


Stress remaining after 1000 hours of CuFePMg (C19700) [Ref: 304]

Each test piece was heated and held at 150°C for 1000 hours and the stress relaxation property of the test was evaluated according to the method of Electronics Materials manufacturers Association of Japan Standard. Specifically , one side of the test piece after heating was held, and the stress under a load 80% of the 0,2 proof stress as an initial stress was determined. This coarse dispersoids containing Mg and P having an average particle diameter exceeding the upper limit. In addition, the alloy has a markedly low electrical conductivity because of excessive P dissolved to form a solid solution and is low in strength, bendability and stress relaxation property.

Stress relaxation of CuFePMg alloys [Ref: 301]

No of alloy	Fe	P	Mg	Proof stress	Stress relaxation rate	Literature
	Wt.%			MPa	%	
1	0,15	0,10	0,25	410	16	[Ref: 301]
3	0,91	0,10	0,25	403	16	
4	0,15	0,02	0,25	415	19	
5	0,15	0,36	0,25	408	15	
6	0,15	0,10	0,10	417	19	
7	0,15	0,10	0,92	405	17	
8	0,15	0,10	0,25	428	15	
9	0,15	0,10	0,25	433	14	
10	0,15	0,10	0,25	440	15	
14	0,00	0,10	0,25	432	15	
15	1,05	0,10	0,25	360	17	
16	0,15	0,00	0,25	418	23	
17	0,15	0,46	0,25	395	22	
18	0,15	0,10	0,04	406	23	
19	0,15	0,10	1,10	400	22	



Stress relaxation degree for CuFePMg alloy [Ref: 301]

Rheological properties and Proof stress of CuFePMg alloys with Ni, Co, Zn and Sn additions [Ref: 301]

Creep

NO DATA AVAILABLE

Wear resistance

Friction resistance

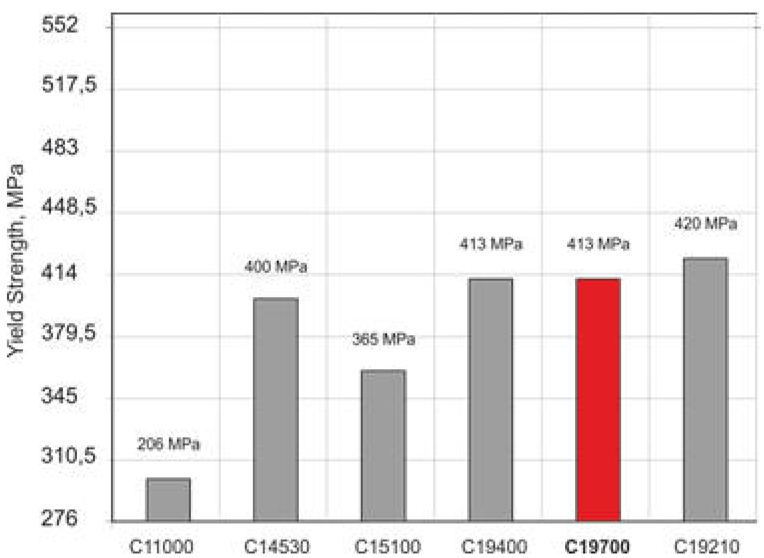
NO DATA AVAILABLE

Fatigue resistance

Fatigue cracking

Bendability of CuFePMg according PMX Industries INC

Temper	90° good way	bad way	Literature
H020	0.5	0.5	[Ref: 298]
Ho40	1	1	
Ho60	1.5	2	
Ho80	2	3	



Typical yield strength available at a 1t 90 degree Good way bend samples 17.5 mmin width [Ref: 304]

A bending test of CuFePMg alloy sheet was performed. A test piece of 10 mm in width and 30 mm in length was taken from each sample, GOOD WAY beneding (the bending axis is perpendicular to the rolling direction) was preformed, and the presence or absence of cracking at the bending portion was visually observed under an optical microscope at a magnification of 50 times. The bendability was evaluated according to the following criteria: Good: no cracking, Fair: slight cracking, Failure: apparent cracking

Bendability of CuFePMg alloy [Ref: 301]

No of alloy	Fe	P	Mg	Proof Stress	Bendability	Literature
	Wt %			MPa		
1	0,15	0,10	0,25	410	good	[Ref: 301]
3	0,91	0,10	0,25	403	good	
4	0,15	0,02	0,25	415	good	
5	0,15	0,36	0,25	408	good	
6	0,15	0,10	0,10	417	good	
7	0,15	0,10	0,92	405	good	
8	0,15	0,10	0,25	428	good	
9	0,15	0,10	0,25	433	good	
10	0,15	0,10	0,25	440	good	
14	0,00	0,10	0,25	432	good	
15	1,05	0,10	0,25	360	good	
16	0,15	0,00	0,25	418	failure	
17	0,15	0,46	0,25	395	good	
18	0,15	0,10	0,04	406	failure	
19	0,15	0,10	1,10	400	fair	

Bendability of CuFePMg alloy [Ref: 301]

Impact strength

NO DATA AVAILABLE

No of alloy	Fe	P	Mg	Ni	Co	Zn	Sn	Proof stress	Stress relaxation rate	Literature
	Wt%							MPa	%	
20	0,10	1,00	0,25	0,20	0,20	0,10	0,10	430	21	[Ref: 301]
21	0,10	0,10	0,25	0,20	0,20	0,10	0,10	392	24	
22	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	24	
23	0,10	0,10	0,25	0,20	0,20	0,10	0,10	421	22	
24	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	25	
25	0,10	0,10	0,25	0,20	0,20	0,10	0,10	420	25	

No of alloy	Fe	P	Mg	Ni	Co	Zn	Sn	Proof stress	Bendability
	wt %							MPa	
20	0,10	1,00	0,25	0,20	0,20	0,10	0,10	430	failure
21	0,10	0,10	0,25	0,20	0,20	0,10	0,10	392	failure
22	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	fair
23	0,10	0,10	0,25	0,20	0,20	0,10	0,10	421	Failure
24	0,10	0,10	0,25	0,20	0,20	0,10	0,10	390	failure
25	0,10	0,10	0,25	0,20	0,20	0,10	0,10	420	fair

Fabrication properties

Fabrication properties	Value	Comments
Soldering	Good	
Brazing	Good	
Hot dip tinning	Excellent	
Laser welding	Good	
Oxyacetylene Welding	Fair	
Gas Shielded Arc Welding	Good	
Coated Metal Arc Welding	Fair	
Spot Weld	Good	
Seam Weld	Good	
Butt Weld	Good	
Capacity for Being Cold Worked	Good	
Capacity for Being Hot Formed	Good	
Forgeability Rating	65	65% of C37700 (forging brass)
Machinability Rating	20	20% of C36000 (free-cutting brass)
[Ref: 254, 91, 267]		

Technological properties

Technological properties	Value	Comments
Melting temperature [°C]	1080-1090	
Annealling temperature [°C]	350-550	
Hot working temperature [°C]	760-930	
[Ref: 254, 91, 267]		

References:

91. **Key to Metals - Data Base** - www.keytometals.com

250. **ASTM B465-04 Standard specification for Copper-Iron Alloy Plate, Sheet, Strip and Rolled Bar** -

252. **Electronic Materials Handbook, vol.1 Packaging** - ASM International

254. **Copper and copper alloys** - J.Davis, ASM International, 2001

255. **Electrical and magnetic properties of metals** - Ch.Moosrugger, ASM International, 2000

256. **Thermal properties of metals** - F.Cverna, ASM International ASM, 2002

257. **Concise Metals** - Engieering Data Book, ASM International, 2004

267. **MatWeb - Data Base** - www.matweb.com

298. **Data sheet - Alloy C19700** - PMX Industries

299. **Data sheet - C19700** - Wieland

300. **Copper alloy having improved stress relaxation** - Patent No 6093265, Jul.25,2000

301. **Copper alloy having bendability and stress relaxation property** - Patent no US2006/0137773A1, Jun.29,2006

304. **Copper alloys having an improved combination of strength and conductivity** - Patent no 4605532, Aug.12.1986