Brand Name	**MANGANIN® 1)**
Material Code	**2.1362**
Abbreviation	**CuMn12Ni**

Chemical Composition (mass components) in %.
Average values of alloy components

Cu	Mn	Ni			
Rem.	12	2			

Features and Application Notes

The precision resistance alloy MANGANIN®, developed by Isabellenhütte, is especially characterized by low temperature coefficient between +20 and +50 °C with a parabolic shape of the R(T) curve, high long-term stability of electrical resistance, extremely low thermal EMF versus copper and good working properties. Due to these features MANGANIN® is the standard material for precision, standard and shunt resistors. MANGANIN® is the basis for the production of ISA-PLAN® and ISA-WELD® components. The maximum working temperature in air is +140 °C. However, higher thermal loads in a non-oxidizing atmosphere are possible. When used for precision resistors with the highest requirements, the resistors should be carefully stabilised and the application temperature should not exceed +60 °C. Exceeding the maximum working temperature in air may result in a resistance drift generated by oxidizing processes. Thus, the long-term stability can be affected negatively. As a result, the resistivity as well as the temperature coefficient of the electric resistance may slightly change. It is also used as low cost replacement material for silver solder for hard metal mounting.

Form of Delivery

MANGANIN® is supplied in the form of round wires in the range 0.02 to 8.00 mm Ø in bare or enamelled condition, also with rayon or silk covering. The product line includes sheets, ribbons, flat wires, stranded wires and rods.

Electrical Resistance in Annealed Condition

Temperature coefficient of electrical resistance between	Electrical resistivity in: µΩ x cm (first line) and Ω /CMF (second line) Reference Values					
+20 °C and +50 °C 10^{-6}/K	+20 °C tolerance ±5 %	+100 °C	+200 °C	+300 °C	+400 °C	+500 °C
±10	**43**	**43**				
	259	**259**				

Physical Characteristics (Reference Values)

Density at +20 °C		Melting point	Specific heat at +20 °C	Thermal conductivity at +20 °C	Average linear thermal expansion coefficient between +20 °C and		Thermal EMF against copper at
					+100 °C	+400 °C	+20 °C
g/cm³	**lb/cub in**	**°C**	**J/g K**	**W/m K**	**10^{-6}/K**	**10^{-6}/K**	**µV/K**
8.40	**0.30**	**+960**	**0.41**	**22.00**	**18.00**	**19.50**	**Stand: -1.00 Special ± 0.20**

Mechanical Properties at +20 °C in Annealed Condition 2)

Tensile Strength 3)		Elongation (L_0 = 100 mm) % at nominal diameter in mm				
MPa	**psi**	0.020 to 0.063	> 0.063 to 0.125	> 0.125 to 0.50	> 0.50 to 1.00	> 1.00
390	**56,550**	**≈ 12**	**≈ 18**	**≈ 20**	**≥ 20**	**≥ 25**

1) MANGANIN® is a registered trademark of Isabellenhütte Heusler GmbH & Co. KG.
2) Other characteristic values are: Modulus of elasticity = 1.3 x 105 MPa, pressure coefficient of electrical resistance = 2.3 x 10^{-7} cm²/N.
3) This value applies to wires of 2.0 mm diameter. For thinner wires the minimum values will substantially increase, depending on the dimensions.

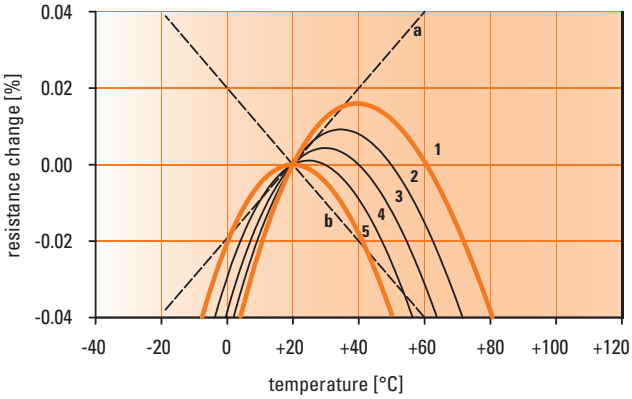
The specifications of the electrical and physical properties generally reference the following standards:

DIN 17 471	Resistance Alloys – Properties
ASTM B267	Standard specification for wires for the production of wirewound resistors
DIN 17 470	Heating conductor alloys – Technical delivery conditions for round and flat wires
ASTM B344	Standard specification for drawn/rolled nickel-chromium and nickel-chromium-iron wires for electric heating elements

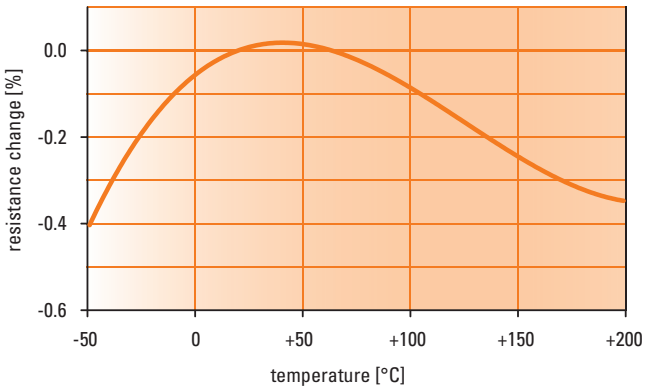
Properties and requirements depend on the material condition (formed, annealed ...) as well as the design (bare, insulated ...) and may deviate from the specified values.

Nominal Diameter	Cross Section	Weight per 1.000 m	DC Resistance Referred to Length at +20 °C Ω/m			
mm	mm²	g	Nominal Value	Tolerance	Minimum Value	Maximum Value
0.020	0.0003142	2.64	1,369	±10 %	1,232	1,506
0.022	0.0003801	3.19	1,131		1,018	1,244
0.025	0.0004909	4.12	876		788	964
0.028	0.0006158	5.17	698		629	768
0.030	0.0007069	5.94	608	±8 %	560	657
0.032	0.0008042	6.76	535		492	577
0.036	0.001018	8.55	422		389	456
0.040	0.001257	10.60	342		315	370
0.045	0.001590	13.40	270		249	292
0.050	0.001963	16.50	219		202	237
0.056	0.002463	20.70	175		161	189
0.060	0.002827	23.80	152		140	164
0.063	0.003117	26.20	138		127	149
0.070	0.003848	32.30	112		103	121
0.071	0.003959	33.30	109		100	117
0.080	0.005027	42.20	85.5		78.7	92.4
0.090	0.006362	53.40	67.6		62.2	73.0
0.100	0.007854	66.00	54.7		50.4	59.1
0.110	0.009503	79.80	45.2	±7 %	42.1	48.4
0.112	0.009852	82.80	43.6		40.6	46.7
0.120	0.01131	95.00	38.0		35.4	40.7
0.125	0.01227	103.00	35.0		32.6	37.5
0.130	0.01327	111.00	32.4		30.1	34.7
0.140	0.01539	129.00	27.9		26.0	29.9
0.150	0.01767	148.00	24.3		22.6	26.0
0.160	0.02011	169.00	21.4		19.9	22.9
0.180	0.02545	214.00	16.9		15.7	18.1
0.200	0.03142	264.00	13.7	±6 %	12.9	14.5
0.220	0.03801	319.00	11.3		10.6	12.0
0.224	0.03941	331.00	10.9		10.3	11.6
0.250	0.04909	412.00	8.76		8.23	9.29
0.280	0.06158	517.00	6.98		6.56	7.40
0.300	0.07069	594.00	6.08		5.72	6.45

Nominal Diameter	Cross Section	Weight per 1.000 m	DC Resistance Referred to Length at +20 °C Ω/m			
mm	mm²	g	Nominal Value	Tolerance	Minimum Value	Maximum Value
0.315	0.07793	655.00	5.52		5.24	5.79
0.350	0.09621	808.00	4.47		4.25	4.69
0.355	0.09898	831.00	4.34		4.13	4.56
0.400	0.1257	1,060.00	3.42	±5 %	3.25	3.59
0.450	0.1590	1,340.00	2.70		2.57	2.84
0.500	0.1963	1,650.00	2.19		2.08	2.30
0.550	0.2376	2,000.00	1.81		1.74	1.88
0.560	0.2463	2,070.00	1.75		1.68	1.82
0.600	0.2827	2,380.00	1.52		1.46	1.58
0.630	0.3117	2,620.00	1.38		1.32	1.43
0.650	0.3318	2,790.00	1.30		1.24	1.35
0.700	0.3848	3,230.00	1.12		1.07	1.16
0.710	0.3959	3,330.00	1.09		1.04	1.13
0.800	0.5027	4,220.00	0.855		0.821	0.890
0.900	0.6362	5,340.00	0.676		0.649	0.703
1.000	0.7854	6,600.00	0.547		0.526	0.569
1.120	0.9852	8,280.00	0.436		0.419	0.454
1.200	1.131	9,500.00	0.380		0.365	0.395
1.250	1.227	10,310.00	0.350		0.336	0.364
1.400	1.539	12,930.00	0.279		0.268	0.291
1.500	1.767	14,840.00	0.243		0.234	0.253
1.600	2.011	16,890.00	0.214		0.205	0.222
1.800	2.545	21,380.00	0.169		0.162	0.176
2.000	3.142	26,390.00	0.137	±4 %	0.131	0.142
2.200	3.801	31,930.00	0.113		0.109	0.118
2.240	3.941	33,100.00	0.109		0.105	0.113
2.500	4.909	41,230.00	0.0876		0.0841	0.0911
2.800	6.158	51,720.00	0.0698		0.0670	0.0726
3.000	7.069	59,380.00	0.0608		0.0584	0.0633
3.150	7.793	65,460.00	0.0552		0.0530	0.0574
3.200	8.042	67,560.00	0.0535		0.0513	0.0556
3.500	9.621	80,820.00	0.0447		0.0429	0.0465
3.550	9.898	83,140.00	0.0434		0.0417	0.0452
4.000	12.57	105,560.00	0.0342		0.0328	0.0356
4.500	15.90	133,600.00	0.0270		0.0260	0.0281
5.000	19.63	164,930.00	0.0219		0.0210	0.0228
5.500	23.76	199,570.00	0.0181		0.0174	0.0188
5.600	24.63	206,890.00	0.0175		0.0168	0.0182
6.000	28.27	237,500.00	0.0152		0.0146	0.0158
6.300	31.17	261,850.00	0.0138		0.0132	0.0143
8.000	50.27	422,230.00	0.00855		0.00821	0.00890



Graph 1: Electrical resistance vs. temperature (range -40 °C bis +120 °C)



Graph 2: Electrical resistance vs. temperature (range -50 °C bis +200 °C)

Notes on Treatment // MANGANIN® can be worked easily. Though the alloy can be soldered, it develops in air a thin oxide film; this must be removed before working. With an appropriate flux MANGANIN® is also suitable for dip-tinning. Furthermore, MANGANIN® can be brazed and welded. Resistors made of MANGANIN® must be aged in order to remove mechanical stress. For further details see Technical Information.

Special Remarks on the Temperature Coefficient (TC) // The graphs on page 4 show the variation of the electrical resistance vs. temperature for different temperature ranges. Because of the parabolic shape of the R(T)-curves in the room temperature range (graph 1) the TC data must be specified with the corresponding temperature range used. The typical curves 1-5 in graph 1 represent different supplied qualities which can be controlled by the alloy composition. A better and for Manganin® typical characterization of the R(T)-curve is therefore the second zero transition, which is the temperature where the resistance is equal to the +20 °C value. The dotted straight lines a and b apply to a TC = ±10 ppm/K.