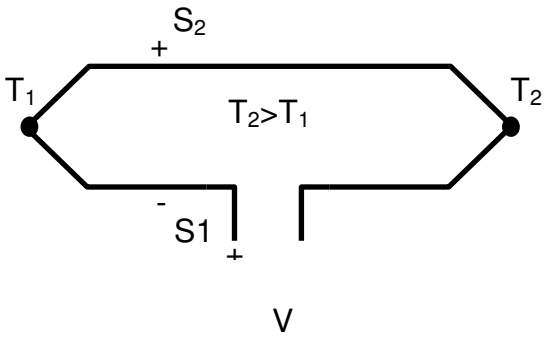
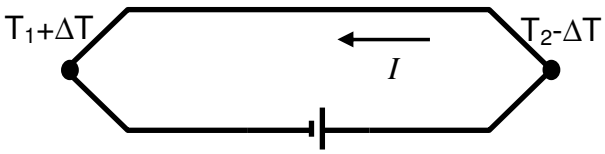
TERMOCUPLAS:



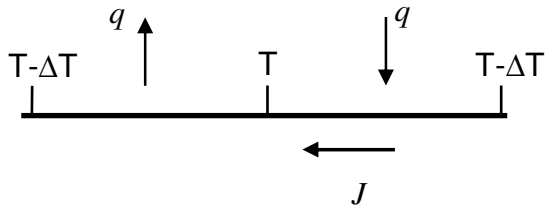
Seebeck (1821) (Sb – Cu)

$$V = (S_2 - S_1) \cdot (T_2 - T_1)$$



Peltier (1834)

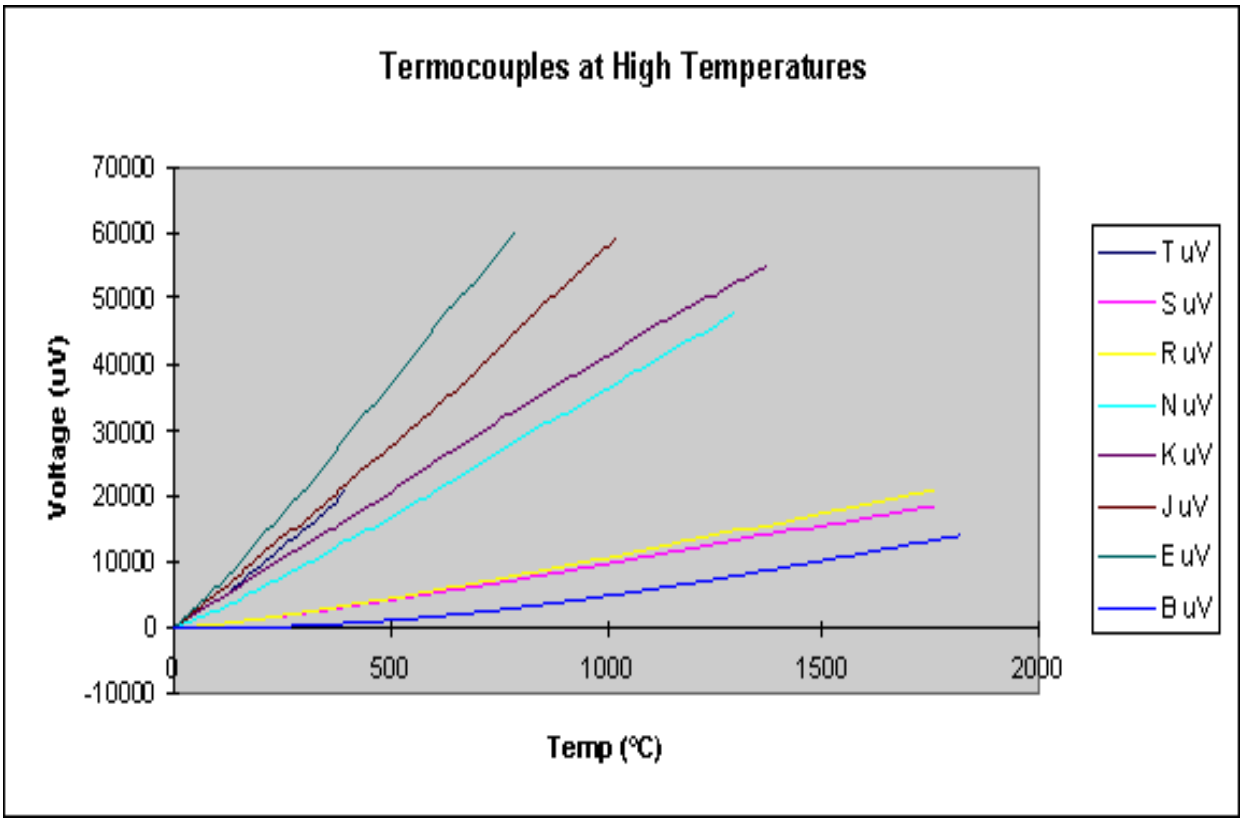
$$\frac{\partial q}{\partial t} = (\Pi_2 - \Pi_1) \cdot I$$

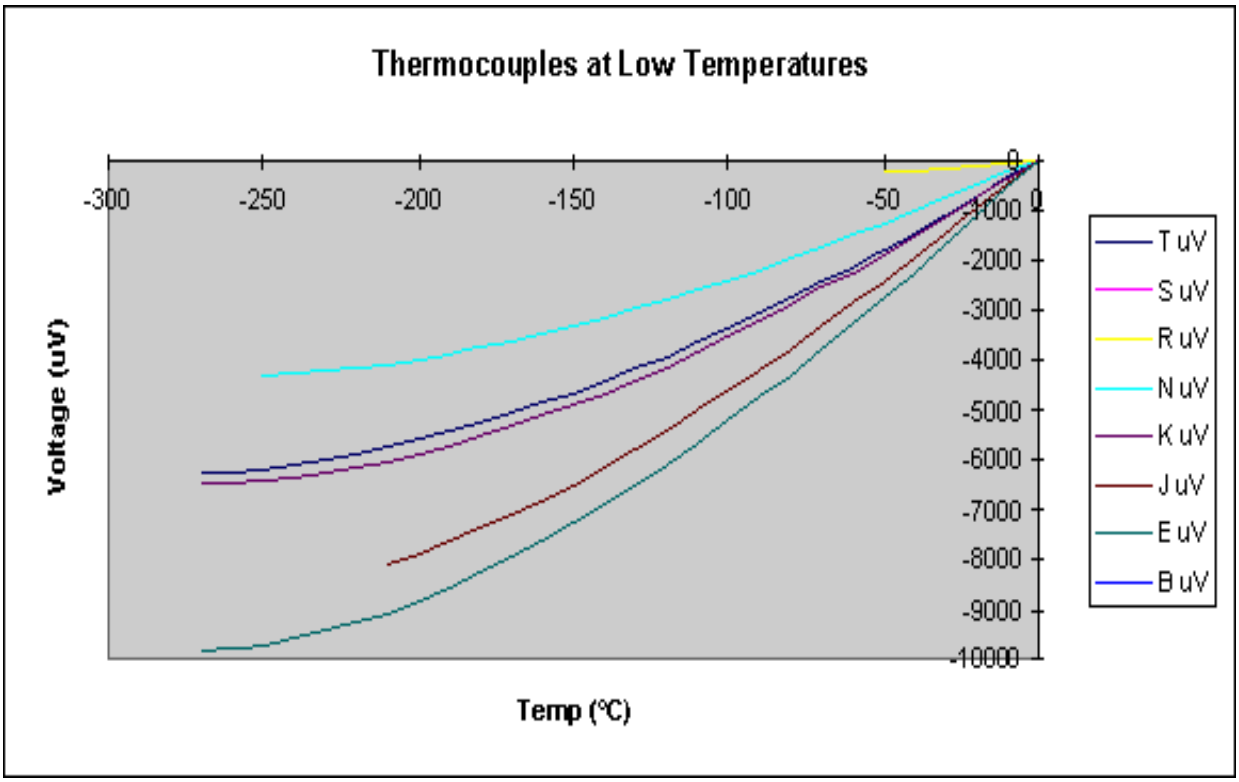


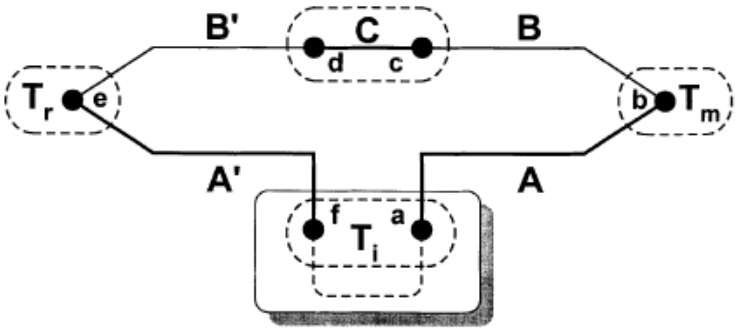
Thomsom (1847)

$$q = \rho \cdot J^2 - \mu \cdot J \cdot \frac{\partial T}{\partial x}$$

JUNCTION MATERIALS	APPROXIMATE SENSITIVITY IN μV/°C AT 25°C	USEFUL TEMPERATURE RANGE (°C)	APPROXIMATE VOLTAGE SWING OVER RANGE	LETTER DESIGNATION
Copper – Constantan	40.6	−270 to + 600	25.0mV	T
Iron – Constantan	51.70	−270 to +1000	60.0mV	J
Chromel – Alumel	40.6	−270 to +1300	55.0mV	K
Chromel – Constantan	60.9	−270 to +1000	75.0mV	E
Platinum 10% – Rhodium/Platinum	6.0	0 to +1550	16.0mV	S
Platinum 13% – Rhodium/Platinum	6.0	0 to +1600	19.0mV	R


Termocouples at High Temperatures
70000
60000
50000
40000
30000
20000
10000
0
-10000
0
500
1000
1500
2000
Voltage (uV)
Temp (°C)
T uV
S uV
R uV
N uV
K uV
J uV
E uV
B uV


Thermocouples at Low Temperatures
-300
-250
-200
-150
-100
-50
0
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
Voltage (uV)
Temp (°C)
T uV
S uV
R uV
N uV
K uV
J uV
E uV
B uV



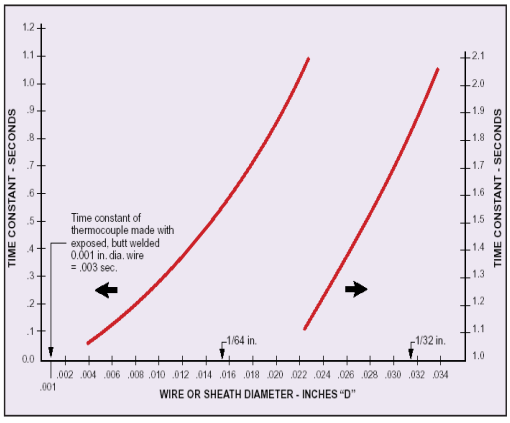
Thermocouple Tip Styles

Grounded Thermocouple

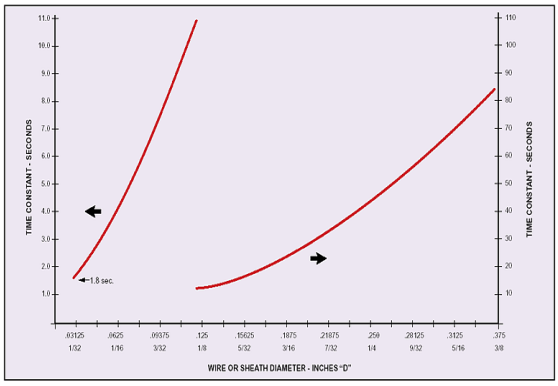
Ungrounded Thermocouple

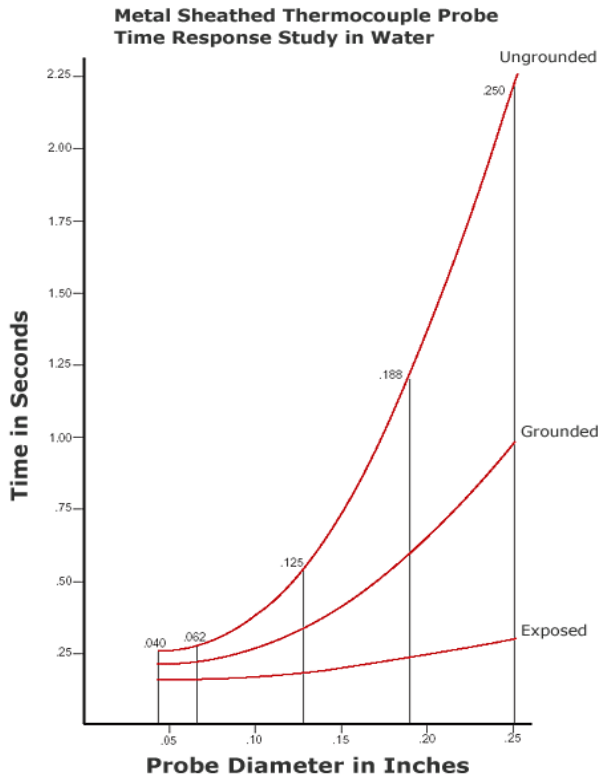
Exposed Thermocouple

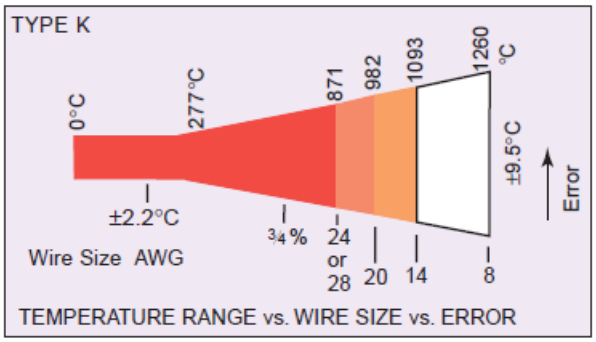
Comparison of Time Constant* vs. Overall Outside Diameter of Bare Thermocouple Wires or Grounded Junction Thermocouples In Air



Because of space limitations, time constant curve is divided into 4 separate curves.





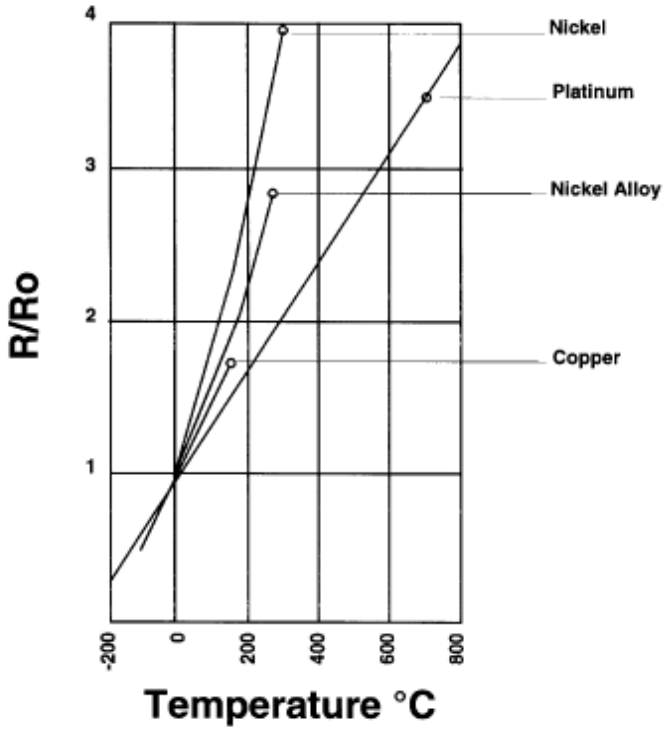


TEMPERATURE RANGE vs. WIRE SIZE vs. ERROR

AWG	DIA, MILS	DIA, mm
8	128	3.3
10	102	2.6
12	81	2.1
14	64	1.6
16	51	1.3
18	40	1
20	32	0.8
22	25	0.6
24	20	0.5
26	16	0.4
28	13	0.3

TYPE	METAL +	METAL -	STANDARD COLOR CODE +	STANDARD COLOR CODE -	Ω/DOUBLE FOOT 20 AWG	SEEBECK COEFFICIENT S(μV/°C) @T (°C)		°C STANDARD WIRE ERROR (SEE APPENDIX B)	NBS SPECIFIED MATERIAL RANGE† (°C)
B	Platinum - 6% Rhodium	Platinum - 30% Rhodium	–		0.2	6	600	4.4 to 8.6	0 to 1820*
E	Nickel - 10% Chromium	Constantan	Violet	Red	0.71	58.5	0	1.7 to 4.4	-270 to 1000
J	Iron	Constantan	White	Red	0.36	50.2	0	1.1 to 2.9	- 210 to 760
K	Nickel - I0% Chromium	Nickel	Yellow	Red	0.59	39.4	0	1.1 to 2.9	-270 to 1372
N (AWG 14)	Nicrosil	Nisil	–		–	39	600	–	0 to 1300
N (AWG 28)	Nicrosil	Nisil	–		–	26.2	0	–	-270 to 400
R	Platinum- 13% Rhodium	Platinum	–		0.19	11.5	600	1.4 to 3.8	-50 to 1768
S	Platinum - 10% Rhodium	Platinum	–		0.19	10.3	600	1.4 to 3.8	-50 to 1768
T	Copper	Constantan	Blue	Red	0.30	38	0	0.8 to 2.9	-270 to 400
W-Re	Tungsten - 5% Rheniurn	Tungsten - 26% Rhenium	–		–	19.5	600	–	0 to 2320

RESISTIVE TEMPERATURE DETECTOR (RTD)



:

$$R(T) = R_0 \cdot (1 + \alpha_1 T + \alpha_2 T^2)$$

$$R_0 = R_{T=0°C}$$

Para Pt:

$\alpha_1 = 3,96.10^{-3}$

$\alpha_2 = 5,83.10^{-6}$

Resistencia de conductores de Cu, usados como extensión:

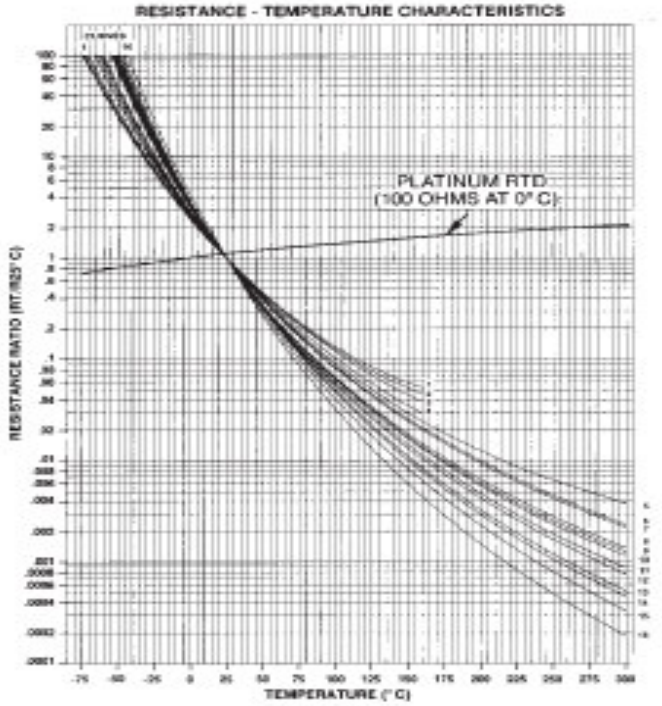
1,3mm	0,013 Ω/m (a 25ºC)
0,4	0,137
0,25	0,35

Resistencia equivalente a 1ºC:

Pt (100 Ω)	0,38 Ω
Pt (500 Ω)	1,9 Ω
Cu (10 Ω)	0,04 Ω
Cu(259)	1 Ω

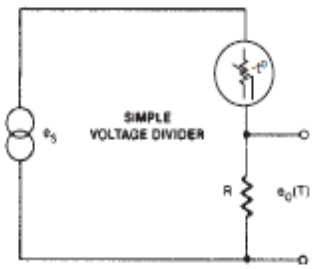
TERMISTORES

THERMOMETRICS, INC.

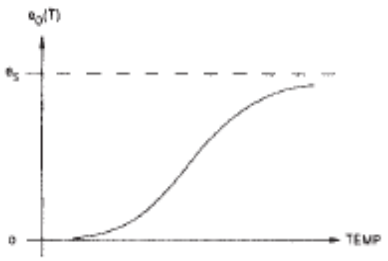


$$R_T = R_{T0} \cdot e^{\beta(\frac{1}{T}-\frac{1}{T0})}$$

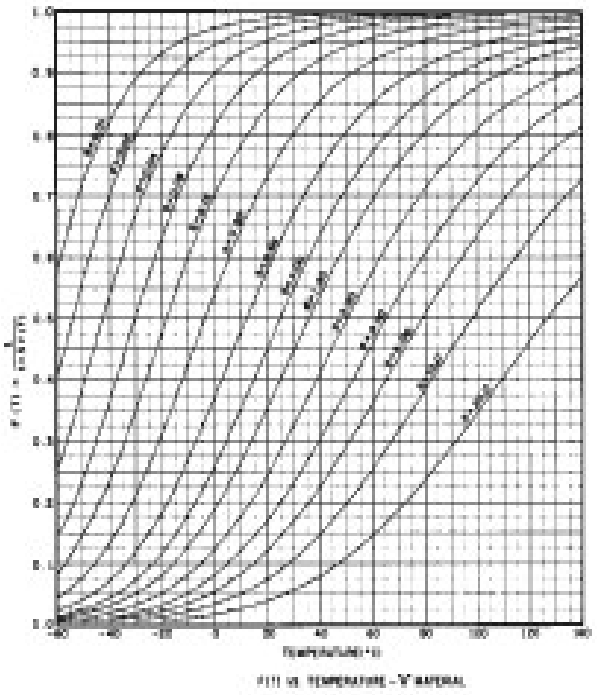
$$\frac{\partial R_T}{\partial T} \cong \text{-2 a -6 \%/ºC}$$



$$r(T) = \frac{R_T}{R_{T0}}$$



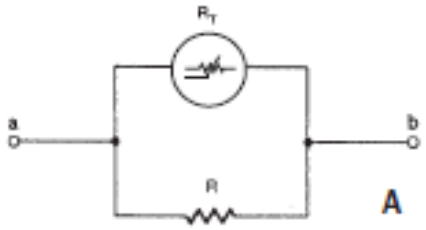
$$e_0(T) = \frac{e_S}{1 + \frac{R_{T0}}{R} \cdot r(T)}$$



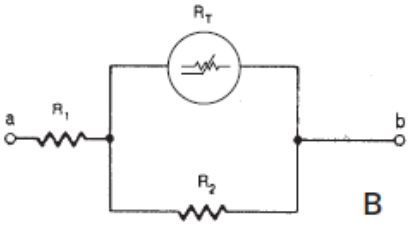
$$r(T)=\frac{R_T}{R_{T0}}$$

$$s=\frac{R_{T0}}{R}$$

$$F(T)=\frac{1}{1+s\cdot r(T)}$$



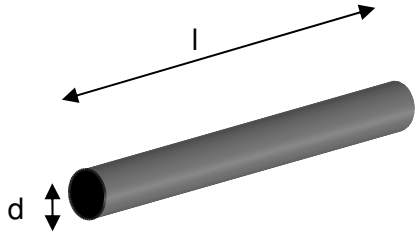
$$R_{ab}=\frac{R_T\cdot R}{R_T+R}=R\cdot\left[1-F(T)\right]$$



$$R_{ab}=R_2\cdot\left[1+\frac{R_1}{R_2}-F(T)\right]$$

STRAIN GAUGES.

$$\frac{\partial R}{R} = G\frac{\partial l}{l}$$



G: Factor de gauge.

$\frac{\partial l}{l}$: microstrains [10^{-6} cm/cm]

$$R = \frac{\rho \cdot l}{A}[\Omega]$$

$$\frac{\partial R}{R} = \frac{\partial \rho}{\rho} + \frac{\partial l}{l} - \frac{\partial A}{A}$$

$$A = \frac{\pi \cdot d^2}{4} \qquad \frac{\partial A}{A} = 2\frac{\partial d}{d}$$

$$V = \frac{\pi \cdot d^2}{4} \cdot l \qquad \frac{\partial V}{V} = 2\frac{\partial d}{d} + \frac{\partial l}{l}$$

Coeficiente de Poisson:

$$\nu = -\frac{\partial d / d}{\partial l / l}$$

Coeficiente de Brigdman:

$$C = \frac{\partial \rho / \rho}{\partial V / V}$$

$$\frac{\partial R}{R} = \frac{\partial l}{l}\left[1 - C(1-2\nu) + 2\nu\right]$$

FACTOR DE GAUGE. $G = \left[1 - C(1-2\nu) + 2\nu\right]$

	Metal	Semiconductor
Rango [με]	0,1 – 40000	0,001 – 3000
Factor de Gauge (G)	2 – 4,5	50 - 200
R [ohms]	120 - 5000	1000 - 5000
ΔR [%]	0,1 – 0,2	1 - 2