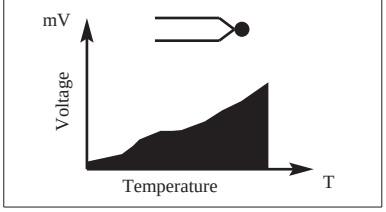
Introduction

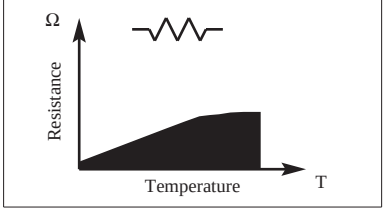
♦ The thermocouple (**TC**) is a very simple and reliable sensor, made by 2 omogeneous metal conductors, chemically different, solded on one end (hot or measure junction) and free on the other one (reference or cold junction).
The temperature difference between the two ends of the thermocouple causes an electromotive force, which is univocally related to it (E.M.F.).
This E.M.F. has a non-linear course, which is shown in the conversion table, referring to the cold junction at 0°C.
♦ The Resistance Thermometer (**TR**) is a passive element made by pure metal material, which resistive value depends on temperature changement.
Used materials might be platinum or Nichel.
Such elements are usually designed in order to have a value equal to 100Ω at 0°C, which grows in linearity with temperature.
The choice of a temperature sensor has to be as a function of the kind of application, considering ambiental conditions, temperature ranges, precision of the measure.
Here is a diagram which could help in the choice either of a TC or of a TR.

FACTORS	*TC*	*TR*
Temperature range	*from -20 to over 2000°C*	*from -200°C to +850°C*
Cost	*Low cost*	*Higher cost*
Power supply	*Not required*	*Required*
Self-heating	*None*	*Present*
Stability	*Good*	*Excellent*
Ruggedness	*Very good*	*Good*
Signal/Output	*(mv) unlinear*	*(Ohm) linear*
Size	*Possibility of very small sizes*	*quite small*
Sensitivity	*At the tip or along the stem*	*Sensitive at the tip*
Vibration Resistance	*More suitable (Mineral Insulated)*	*Less suitable*

Thermocouple



Resistance Thermometer



TC / RT and Working Temperature Limits

Symbol	*Thermocouple Type*	*Temperature range*	*Max. Temperature as a function of wire ø*							
ANSI	*Calibration*	*°C*	*0.35*	*0.51*	*0.81*	*1.02*	*1.29*	*1.63*	*2.30*	*3.26*
T	*Copper-Constantan*	*-200 ÷ +390° C*	*/*	*200°*	*260°*	*/*	*/*	*390°*	*/*	*/*
J	*Iron-Constantan*	*-200 ÷ +760° C*	*/*	*370°*	*480°*	*500°*	*540°*	*590°*	*690°*	*760°*
E	*Chromel-Costantan*	*-200 ÷ +990° C*	*/*	*430°*	*540°*	*570°*	*600°*	*650°*	*900°*	*990°*
K	*Chromel-Alumel*	*-200 ÷ +1270° C*	*/*	*960°*	*980°*	*1000°*	*1040°*	*1060°*	*1090°*	*1270°*
S	*Platinum 10% Rhodium-Platinum*	*0 ÷ +1450°C*	*1380°*	*1760°*	*/*	*/*	*/*	*/*	*/*	*/*
R	*Platinum 13% Rhodium-Platinum*	*0 ÷ +1760° C*	*1380°*	*1760°*	*/*	*/*	*/*	*/*	*/*	*/*
B	*Platinum 30% Rhodium - Plat. 6 % Rhod.*	*0 ÷ +1820° C*	*1460°*	*1820°*	*/*	*/*	*/*	*/*	*/*	*/*

The limit of the working temperature of a thermocouple depends on the diameter of the wires of the element: as bigger is the diameter of the wires, as bigger is the max. tolerable temperature.
By the same working temperature, a thermocouple with thicker wires will have a longer life, but a slower answer time.

Symbol	*RT Type*	*Temperature Range (° C)*
PT100	*Platinum*	*-200 ÷ +850° C*
NI100	*Nichel*	*-60 ÷ +180° C*

Precision Classes

Type		Tolerance Class 1	Tolerance Class 2	Tolerance Class 3
T	Temperature Range	-40 ... +125° C	-40 ... +133° C	-67 ... +40°C
	Tolerance	±0.5° C	±1° C	±1° C
	Temperature Range	+125 ... +350°C	+133 ... +350° C	-200 ... -67° C
	Tolerance	±0.004 [t]	±0.0075 [t]	±0.015 [t]
E	Temperature Range	-40 ... +375° C	-40 ... +333° C	-167 ... +40°C
	Tolerance	±1.5° C	±2.5° C	±2.5° C
	Temperature Range	+375 ... +800°C	+333 ... +900° C	-200 ... -167° C
	Tolerance	±0.004 [t]	±0.0075 [t]	±0.015 [t]
J	Temperature Range	-40 ... +375° C	-40 ... +333° C	-
	Tolerance	±1.5° C	±2.5° C	-
	Temperature Range	+375 ... +750°C	+333 ... +750° C	-
	Tolerance	±0.004 [t]	±0.0075 [t]	-
K	Temperature Range	-40 ... +375° C	-40 ... +333° C	-167 ... +40°C
	Tolerance	±1.5° C	±2.5° C	±2.5° C
	Temperature Range	+375 ... +1000°C	+333 ... +1200° C	-200 ... -167° C
	Tolerance	±0.004 [t]	±0.0075 [t]	±0.015 [t]
R, S	Temperature Range	0 ... +1100° C	-0 ... +600° C	-
	Tolerance	±1° C	±1.5° C	-
	Temperature Range	+1100 ... +1600°C	+600 ... +1600° C	-
	Tolerance	±[1+0.003(t-1100)]° C	±0.0025 [t]	-
B	Temperature Range	-	-	+600 ... +800° C
	Tolerance	-	-	+4° C
	Temperature Range	-	+600 ... +1700° C	+800 ... +1700° C
	Tolerance	-	±0.0025 [t]	±0.005 [t]

Tolerance classes for thermocouples (reference junction at 0°C) **- IEC 584.2 Standards -**

Temperature	*Tolerance*			
	Class A		*Class B*	
(°C)	*(±°C)*	*(±Ω)*	*(±°C)*	*(±Ω)*
-200	0,55	0,24	1,3	0,56
-100	0,35	0,14	0,8	0,32
0	0,15	0,06	0,3	0,12
100	0,35	0,13	0,8	0,30
200	0,55	0,20	1,3	0,48
300	0,75	0,27	1,8	0,64
400	0,95	0,33	2,3	0,79
500	1,15	0,38	2,8	0,93
600	1,35	0,43	3,3	1,06
650	1,45	0,46	3,6	1,13
700	-	-	3,8	1,17
800	-	-	4,3	1,28
850	-	-	4,6	1,34

Tolerance classes for PT100 resistance thermometers
- IEC 751 - DIN 43760 Standards

0° C	± 0,40° C

Tolerance class for Ni100 resistance thermometers
- DIN 43760 Standards -

DIN 43760 IEC 751		Precision at 0°C
B	1 DIN	± 0,3° C
A	1/2 DIN	± 0,15° C
-	1/3 DIN	± 0,1° C
-	1/5 DIN	± 0,06° C
-	1/10 DIN	± 0,03° C

Mineral Insulated Sensors

Such sensors are used with thermoelements insulated by the metal sheath by means of metal mineral oxide powder firmly compressed.
The mostly used material is magnesium oxide.
The main properties of this type of sensor are:

♦ **Long Working Life of the Element**
Due to the complete protection from the effects of chemical products and heat.

♦ **Mechanical Protection**
The compactness of the mineral insulated cable protects the wires and keeps them aligned even when the sheath is twisted or bent.

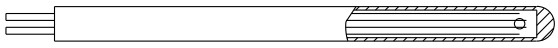
♦ **Electrical Protection**
The metal sheath screens the thermocouple from electrical interference.

♦ **Insulation Protection**
The magnesium oxide retains its insulating properties at high temperature and humidity, the homogeneity of the external sheath protects the thermocouple wires from gasses and liquids at high pressure.

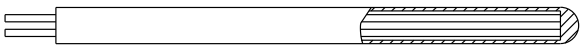
♦ **Ease of Installation**
The flexible construction means that the thermocouple can be inserted into curved areas and can take up any required shape.
Here is a table with indicative max. temperature values, which can be reached depending on the sheath diameter of the thermocouple.

Sheath ø mm	*MgO K T. max ° C*	*MgO J T. max ° C*	*MgO T T. max ° C*	*MgO E T. max ° C*
1	*750*	*320*	-	-
1.5	*870*	*340*	*190*	-
2	*960*	*370*	-	-
3	*970*	*390*	*240*	*450*
4.5	*980*	*480*	*260*	*545*
6	*1050*	*550*	*310*	*595*
8	*1090*	*640*	-	-

Thermocouple Hot Junction



UNGROUNDED HOT JUNCTION
The best solution in applications in the presence of parasitic currents



GROUNDED HOT JUNCTION
Used in the presence of gasses and liquids at high pressure and for fast response times

Resistance Thermometers Connections

Resistance thermometers can have a two, three or four-wire connection.
In the two wire connection measurement and supply of the resistance thermometer are obtained by one conductor only.
In the three-wire connection the third conductor used in the measurement compensates the voltage drop related to the conductor.
In the four-wire connection the voltage drop is compensated in both couples of conductors.