# The Electrical Resistance and its Temperature Coefficient

## Resistivity

See following equation

$$R_t = \frac{\rho_t \cdot l}{q}$$

$R_t$ =Resistance in $\Omega$ at Temperature t

$l$ =Length in m

$q$ =Cross sectional area in $mm^2$

$\rho_t$ =Resistivity in $\Omega \cdot mm^2 \cdot m^{-1}$ at Temperature t

The electric resistance of a conductor at temperature t is proportional to its length and inversely proportional to its cross-sectional area only when the whole test length has constant cross section.

In order to calculate

$$\rho_t = R_t \cdot \frac{q}{l}$$

$R_t$, $q$ and $l$ are determined. If $q$ =1mm$^2$ and $l$ =1m, then one calculates the resistivity.

The practical determination of the resistivity can be difficult, because determination of the cross-sectional area of wires with non-circular cross-section or very thin wires is difficult. In such cases, the cross-sectional area is determined on the basis of weight and length.

The resistivity of a wire can be then determined by following equation:

$$\rho_t = \frac{R_t \cdot g}{\gamma} \cdot \frac{1}{l^2}$$

$R_t$ =Resistance in $\Omega$ at Temperature t

$\rho_t$ =Resistivity in $\Omega \cdot mm^2 \cdot m^{-1}$ at Temperature t

g=Weight in g

$\gamma$ =Density in $\gamma$ /cm$^3$

$l$ =Length in m

**Resistance per Meter**

The resistance per meter of a conductor is determined by the quotient of its resistivity and cross-sectional values.

$$\text{Resistance per Meter} = \frac{Resistivity(\Omega \cdot mm^2 \cdot m^{-1})}{Cross-sectional area(mm^2)} = \Omega \cdot m^{-1}$$

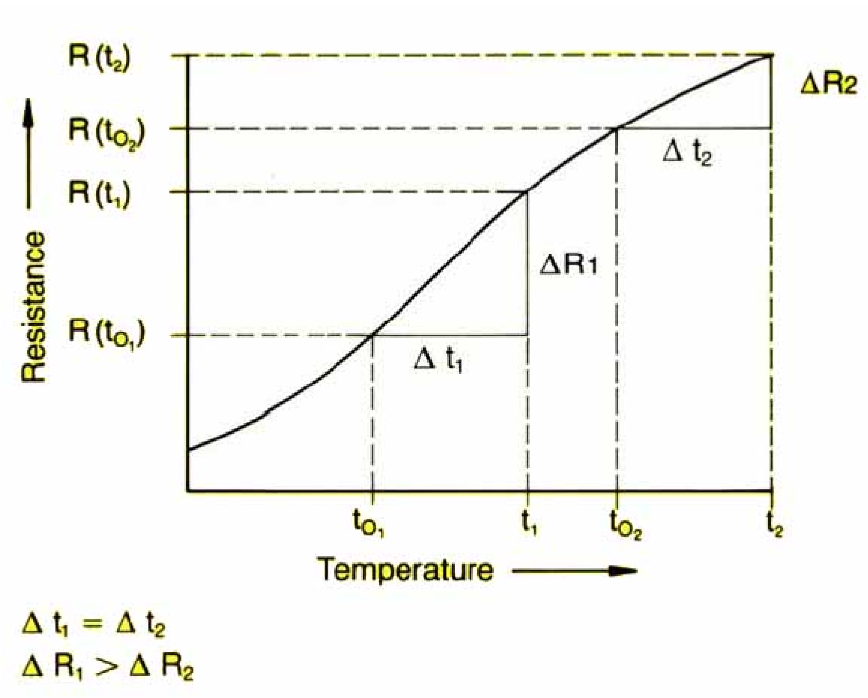
**The Temperature Coefficient ( $\alpha$ ) of Resistivity**

Metals and their alloys exhibit a dependence of the resistivity on temperature. In general the resistivity increases with temperature, dependence of resistivity can be expressed by equation:

$$R_t = R_o[1+\alpha(t-t_o)]$$

This equation applies only if resistance and temperature expose a linear relationship in the test temperature range from $t_o$ to t. for most alloys and metals this is not the case, especially as regards large temperature intervals. In order to deliver an exact description of the temperature dependence of the resistivity, complicated equations are required:

$$\alpha = \frac{R_t - R_o}{R_o(t-t_o)}[K^{-1}]$$




When experimentally determining the temperature coefficient as well as during communication between supplier and customer two points must be observed:

1, As already mentioned, the temperature dependence of the resistivity in general does not show a linear, but a curved form. This applies particularly to certain resistance alloys and is the reason why differing temperature coefficients result from the calculations, because they depend on the part of the curve which corresponds to a certain $\Delta t$ (see figure above).

2, due to the fact that the temperature dependent resistance variation is referred to the resistance value $R_o$ when defining the temperature coefficient values of $R_o$, even if the temperature intervals chosen are of equal width. This means that together with the value of the temperature coefficient the temperature interval from ℃ to ℃ must always be quoted. Comparison of test results is possible only if the test conditions are the same.

In some alloys the temperature coefficient can be controlled by combining certain alloy components. It can be achieve negative values or values around 0 between room temperature and appr. 100℃.

**Temperature Coefficient for Resistance Alloys (Temperature-Resistance Factor)**

| Grade | 20℃ | 100℃ | 200℃ | 300℃ | 400℃ | 500℃ | 600℃ | 700℃ | 800℃ | 900℃ | 1000℃ | 1100℃ | 1200℃ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ni80Cr20 | 1.000 | 1.006 | 1.012 | 1.018 | 1.025 | 1.026 | 1.018 | 1.010 | 1.008 | 1.010 | 1.014 | 1.021 | 1.025 |
| Ni70Cr30 | 1.000 | 1.007 | 1.016 | 1.028 | 1.038 | 1.044 | 1.036 | 1.030 | 1.028 | 1.029 | 1.033 | 1.037 | 1.043 |
| Ni60Cr15 | 1.000 | 1.011 | 1.024 | 1.038 | 1.052 | 1.064 | 1.069 | 1.073 | 1.078 | 1.088 | 1.095 | 1.109 | - |
| Ni35Cr20 | 1.000 | 1.029 | 1.061 | 1.090 | 1.115 | 1.139 | 1.157 | 1.173 | 1.188 | 1.208 | 1.219 | 1.228 | - |
| Ni30Cr20 | 1.000 | 1.023 | 1.052 | 1.079 | 1.103 | 1.125 | 1.141 | 1.158 | 1.173 | 1.187 | 1.201 | 1.214 | 1.226 |
| Cr25Al5 | 1.000 | 1.002 | 1.005 | 1.008 | 1.013 | 1.021 | 1.030 | 1.038 | 1.040 | 1.042 | 1.044 | 1.046 | 1.047 |
| Cr23Al5 | 1.000 | 1.002 | 1.007 | 1.014 | 1.024 | 1.036 | 1.056 | 1.064 | 1.070 | 1.074 | 1.078 | 1.081 | 1.084 |
| Cr20Al4 | 1.000 | 1.011 | 1.025 | 1.042 | 1.061 | 1.085 | 1.120 | 1.142 | 1.154 | 1.164 | 1.172 | 1.180 | 1.186 |