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Resistivity, Conductivity and Temperature Coefficients for some Common Materials

Resistivity, conductivity and temperature coefficients for some common materials as silver, gold, platinum, iron and more - Including a tutorial explanation of resistivity and conductivity

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The factor in the resistance which takes into account the nature of the material is the resistivity.

Resistivity is the

- resistance of a unit cube of the material measured between the opposite faces of the cube

Material	Resistivity Coefficient 2) - ρ - (ohm m)	Temperature Coefficient 2) (per degree C, 1/°C)	Conductivity - σ - (1 /Ωm)
Aluminum	2.65×10^{-8}	3.8×10^{-3}	3.77×10^{7}
Animal fat			14×10^{-2}
Animal muscle			0.35
Antimony	41.8×10^{-8}		
Barium (0°C)	30.2×10^{-8}		
Beryllium	4.0×10^{-8}		
Bismuth	115×10^{-8}		
Brass - 58% Cu	5.9×10^{-8}	1.5×10^{-3}	
Brass - 63% Cu	7.1×10^{-8}	1.5×10^{-3}	
Cadmium	7.4×10^{-8}		
Caesium (0°C)	18.8×10^{-8}		
Calcium (0°C)	3.11×10^{-8}		
Carbon (graphite)1)	$3 - 60 \times 10^{-5}$	-4.8×10^{-4}	
Cast iron	100×10^{-8}		
Cerium (0°C)	73×10^{-8}		
Chromel (alloy of chromium and aluminum)		0.58×10^{-3}	
Chromium	13×10^{-8}		
Cobalt	9×10^{-8}		
Constantan	49×10^{-8}	3×10^{-5}	0.20×10^{7}
Copper	1.724×10^{-8}	4.29×10^{-3}	5.95×10^{7}
Dysprosium (0°C)	89×10^{-8}		
Erbium (0°C)	81×10^{-8}		
Eureka		0.1×10^{-3}	
Europium (0°C)	89×10^{-8}		
Gadolium	126×10^{-8}		
Gallium (1.1K)	13.6×10^{-8}		
Germanium1)	$1 - 500 \times 10^{-3}$	-50×10^{-3}	
Glass	$1 - 10000 \times 10^{9}$		10^{-12}
Gold	2.24×10^{-8}		
Graphite	800×10^{-8}	-2.0×10^{-4}	
Hafnium (0.35K)	30.4×10^{-8}		
Holmium (0°C)	90×10^{-8}		
Indium (3.35K)	8×10^{-8}		
Iridium	5.3×10^{-8}		
Iron	9.71×10^{-8}	6.41×10^{-3}	1.03×10^{7}
Lanthanum (4.71K)	54×10^{-8}		
Lead	20.6×10^{-8}		0.45×10^{7}
Lithium	9.28×10^{-8}		

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Magnesium	4.45×10^{-8}		
Manganese	185×10^{-8}	1.0×10^{-5}	
Mercury	98.4×10^{-8}	8.9×10^{-3}	0.10×10^{7}
Mica	1×10^{13}		
Mild steel	15×10^{-8}	6.6×10^{-3}	
Molybdenum	5.2×10^{-8}		
Neodymium	61×10^{-8}		
Nichrome (alloy of nickel and chromium)	$100 - 150 \times 10^{-8}$	0.40×10^{-3}	
Nickel	6.85×10^{-8}	6.41×10^{-3}	
Nickeline	50×10^{-8}	2.3×10^{-4}	
Niobium (Columbium)	13×10^{-8}		
Osmium	9×10^{-8}		
Palladium	10.5×10^{-8}		
Phosphorus	1×10^{12}		
Platinum	10.5×10^{-8}	3.93×10^{-3}	0.943×10^{7}
Plutonium	141.4×10^{-8}		
Polonium	40×10^{-8}		
Potassium	7.01×10^{-8}		
Praseodymium	65×10^{-8}		
Promethium	50×10^{-8}		
Protactinium (1.4K)	17.7×10^{-8}		
Quartz (fused)	7.5×10^{17}		
Rhenium (1.7K)	17.2×10^{-8}		
Rhodium	4.6×10^{-8}		
Rubber - hard	$1 - 100 \times 10^{13}$		
Rubidium	11.5×10^{-8}		
Ruthenium (0.49K)	11.5×10^{-8}		
Samarium	91.4×10^{-8}		
Scandium	50.5×10^{-8}		
Selenium	12.0×10^{-8}		
Silicon[1)]	0.1-60	-70×10^{-3}	
Silver	1.59×10^{-8}	6.1×10^{-3}	6.29×10^{7}
Sodium	4.2×10^{-8}		
Soil, typical ground			$10^{-2} - 10^{-4}$
Solder	15×10^{-8}		
Stainless steel			10^{6}
Strontium	12.3×10^{-8}		
Sulfur	1×10^{17}		
Tantalum	12.4×10^{-8}		
Terbium	113×10^{-8}		
Thallium (2.37K)	15×10^{-8}		
Thorium	18×10^{-8}		
Thulium	67×10^{-8}		
Tin	11.0×10^{-8}	4.2×10^{-3}	
Titanium	43×10^{-8}		
Tungsten	5.65×10^{-8}	4.5×10^{-3}	1.79×10^{7}
Uranium	30×10^{-8}		
Vanadium	25×10^{-8}		
Water, distilled			10^{-4}
Water, fresh			10^{-2}
Water, salt			4
Ytterbium	27.7×10^{-8}		
Yttrium	55×10^{-8}		
Zinc	5.92×10^{-8}	3.7×10^{-3}	
Zirconium (0.55K)	38.8×10^{-8}		

1) Note! - the resistivity depends strongly on the presence of impurities in the material.

2) Note! - the resistivity depends strongly on the temperature of the material. The table above is based on 20^{o}C reference.

The electrical resistance of a wire is greater for a longer wire and less for a wire of larger cross sectional area. The resistance depend on the material of which it is made and can be expressed as:

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R = resistance (ohm, Ω)

ρ = resistivity coefficient (ohm m, Ω m)

L = length of wire (m)

A = cross sectional area of wire (m^2)

The factor in the resistance which takes into account the nature of the material is the resistivity. Since it is temperature dependent, it can be used to calculate the resistance of a wire of given geometry at different temperatures.

The inverse of resistivity is called conductivity and can be expressed as:

$\sigma = 1 / \rho \qquad (2)$

where

σ = conductivity (1 / Ω m)

Example - Resistance in an Aluminum Cable

Resistance of an aluminum cable with length *10 m* and cross sectional area of $3\ mm^2$ can be calculated as

$R = (2.65\ 10^{-8}\ \Omega\ m)\ (10\ m) / ((3\ mm^2)\ (10^{-6}\ m^2/mm^2))$

$= \underline{0.09}\ \Omega$

Resistance

The electrical resistance of a circuit component or device is defined as the ratio of the voltage applied to the electric current which flows through it:

$R = V / I \qquad (3)$

where

R = resistance (ohm)

V = voltage (V)

I = current (A)

Ohm's Law

If the resistance is constant over a considerable range of voltage, then Ohm's law,

$I = V / R \qquad (4)$

can be used to predict the behavior of the material.

Temperature Coefficient of Resistance

The electrical resistance increases with temperature. An intuitive approach to temperature dependence leads one to expect a fractional change in resistance which is proportional to the temperature change:

$dR / R_s = \alpha\ dT \qquad (5)$

where

dR = change in resistance (ohm)

R_s *= standard resistance according reference tables (ohm)*

α = temperature coefficient of resistance

dT = change in temperature (K)

(5) can be modified to:

$dR = \alpha\ dT\ R_s \qquad (5b)$

Example - Resistance of a Carbon resistor when changing Temperature

A carbon resistor with resistance 1 kΩ is heated 100 ^oC. With a temperature coefficient $-4.8 \times 10^{-4}\ (1/^oC)$ the resistance change can be calculated as

$dR = (-4.8 \times 10^{-4}\ 1/^oC)\ (100\ ^oC)\ (1\ k\Omega)$

$= \underline{-\ 0.048}\ (k\Omega)$

The resulting resistance for the resistor

$R = (1\ k\Omega) - (0.048\ k\Omega)$

$= \underline{0.952}\ (k\Omega)$

$= \underline{952}\ (\Omega)$

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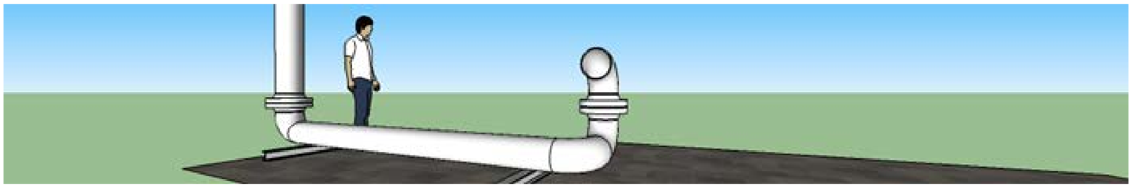

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Length

m
km
in
ft
yards
miles
nautical miles

Volume

m^3
liters
in^3
ft^3
us gal

Velocity

m/s
km/h
ft/min
ft/s
mph
knots

Pressure

Pa (N/m^2)
bar
mm H_2O
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