It can also be written:

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} = \frac{A_1}{A_2}$$

If we have a conductor that is 1 meter (m) long with a cross-sectional area of 1 (millimeter) mm^2 and has a resistance of 0.017 ohm, what is the resistance of 50 m of wire from the same material but with a cross-sectional area of 0.25 mm^2?

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} = \frac{A_1}{A_2}$$

$$R^2 = 0.017\ \Omega \times \frac{50\ \text{m}}{1\ \text{m}} \times \frac{1\ \text{mm}^2}{0.25\ \text{mm}^2} = 3.4\ \Omega$$

While the SI units are commonly used in the analysis of electric circuits, electrical conductors in North America are still being manufactured using the foot as the unit length and the mil (one thousandth of an inch) as the unit of diameter. Before using the equation $R = {}^{(\rho \times l)}\!/_{A}$ to calculate the resistance of a conductor of a given American wire gauge (AWG) size, the cross-sectional area in square meters must be determined using the conversion factor 1 mil = 0.0254 mm. The most convenient unit of wire length is the foot. Using these standards, the unit of size is the mil-foot. Thus, a wire has unit size if it has a diameter of 1 mil and length of 1 foot.

In the case of using copper conductors, we are spared the task of tedious calculations by using a table as shown in *Figure 12-43*. Note that cross-sectional dimensions listed on the table are such that each decrease of one gauge number equals a 25 percent increase in the cross-sectional area. Because of this, a decrease of three gauge numbers represents an increase in cross-sectional area of approximately 2:1. Likewise, change of ten wire gauge numbers represents a 10:1 change in cross-sectional area—also, by doubling the cross-sectional area of the conductor, the resistance is cut in half. A decrease of three wire gauge numbers cuts the resistance of the conductor of a given length in half.

Rectangular Conductors (Bus Bars)

To compute the cross-sectional area of a conductor in square mils, the length in mils of one side is squared. In the case of a rectangular conductor, the length of one side is multiplied by the length of the other. For example, a common rectangular bus bar (large, special conductor) is ⅜ inch thick and 4 inches wide. The ⅜-inch thickness may be expressed as 0.375 inch. Since 1,000 mils equal 1 inch, the width in inches can be converted to 4,000 mils. The cross-sectional area of the rectangular conductor is found by converting 0.375 to mils (375 mils × 4,000 mils = 1,500,000 square mils).

AWG Number	Diameter in mils	Ohms per 1,000 ft.
0000	460.0	0.04901
000	409.6	0.06180
00	364.8	0.07793
0	324.9	0.09827
1	289.3	0.1239
2	257.6	0.1563
3	229.4	0.1970
4	204.3	0.2485
5	181.9	0.3133
6	162.0	0.3951
8	128.5	0.6282
10	101.9	0.9989
12	80.81	1.588
14	64.08	2.525
16	50.82	4.016
18	40.30	6.385
20	31.96	10.15
22	25.35	16.14
24	20.10	25.67
26	15.94	40.81
28	12.64	64.9
30	10.03	103.2

Figure 12-43. *Conversion table when using copper conductors.*

Power and Energy

Power in an Electrical Circuit

This section covers power in the DC circuit and energy consumption. Whether referring to mechanical or electrical systems, power is defined as the rate of energy consumption or conversion within that system—that is, the amount of energy used or converted in a given amount of time.

From the scientific discipline of physics, the fundamental expression for power is:

$$P = \frac{\mathcal{E}}{t}$$

Where
P = power measured in watts (W)
$\mathcal{E}$ = energy ($\mathcal{E}$ is a script E) measured in joules (J)
and
t = time measured in seconds (s)