TECHNICAL ARTICLE #8

Wire Gauges & Strandings

PROS & CONS

Wire Gauge

The common standard for the diameter (gauge) of round drawn wire is the American Wire Gauge (AWG).

As strands of wire are made, they are drawn through progressively smaller dies. This is true of all wire. In fact, the AWG sizing system suggests this drawing procedure. For example, a size 22 AWG wire, smaller than 20 AWG, is drawn, theoretically, through 22 progressively smaller dies. Larger wire is drawn through fewer dies; hence, the lower number "gauge." See Table 1.

Bare Annealed Copper

AWG	Dia (in.)	Circular Mils	Ohms per 1000 ft.	Lbs per 1000 ft.
10	0.1000	10000	1.00	31.43
12	0.0791	6250	1.60	19.77
14	0.0633	4000	2.50	12.43
16	0.0500	2500	4.00	7.818
18	0.0395	1563	6.40	4.917
20	0.0316	1000	10.0	3.092
22	0.0250	625	16.0	1.945
24	0.0200	400	25.0	1.223
26	0.0158	250	40.0	0.769
28	0.0125	156	64.0	0.484
30	0.0100	100	100	0.304
32	0.0079	63	160	0.191
34	0.0063	40	250	0.120
36	0.0050	25	400	0.076
38	0.0040	16	640	0.048
40	0.0032	10	1000	0.030

Table 1. Chart of wire sizes. Circular Mils is the square of the diameter in thousandths, and is useful for comparison of the cross-sectional area of a conductor.

But there's some background to these numbers which may help lend some "rhyme & reason" to how they relate… and in fact will provide a means of relating one gauge to another.

Factor 1 - Every three gauge numbers (#20 to #23, for example) represents a division (or multiplication) of the cross-section and resistance by a factor of 2. Or, referring to the table, which lists only even-numbered gauges, AWG #20 vs #26 would yield a factor of 4. To illustrate, #20 AWG copper wire has a cross section of 1,000 circular mils (CM) and resistance/1000 ft of 10 ohms. #26 AWG, which is smaller, will have a cross section of 250 CM and resistance of 40 ohms. (All values are nominal.)

Factor 2 - Every 10 gauge numbers (#20 to #30 AWG, for example) represents a 10-fold increase or decrease in cross section and resistance. Example: #30 AWG wire is 100 CM (1/10 that of #20 AWG) and 100 ohms per 1,000 feet (10 times that of #20 AWG).

Factor 3 - As a basis for all these numbers, #10 AWG copper is 1 ohm per 1,000 feet.

Having knowledge of these factors can help to simply calculate (or at least estimate) these wire parameters.

Stranded vs. Solid

Well, they are clearly different in appearance, though their purpose is the same. It stands to reason stranded construction would be more flexible. So unless you actually want stiffness—to push a wire through an opening, for example—wouldn't stranded appear to be the better choice?

Then, too, there's strength in numbers: rope, for example, is made of many parallel fibers—individually weak, but together quite strong. If one fiber breaks, there are many left to carry the load.

House wiring is generally solid; wiring for machine tools, automobiles, and aircraft is almost all stranded—for flexibility and redundancy in the face of vibration.

The application dictates the choice of conductor type. At high frequencies—above, say, 1,000 MHz—conductivity relies more on the surface of the conductor than its core. This is the "skin effect," and the reason silver plating becomes important. This also applies in very high current situations—beyond that experienced in the typical aircraft situation, but occurring in major power distribution grids, for example.

The center conductors of some land-based high-power RF antenna feeds, where size and flexibility are not issues,may actually be a hollow tube—giving further evidence to the relative unimportance of the interior of the wire as a conductor in such applications.

With adequate support by the insulation—as with coaxial cable—a solid conductor will survive the vibration and yet carry an RF signal more efficiently than its stranded counterpart.

This is not meant to imply that all good RF cables should have solid conductors; for the sake of flexibility, some coaxes often have stranded, silver-plated center conductors and work very well.

As always, trade-offs are omnipresent.

Stranding

Conductor[1]	Factors[2]	Conductor[1]	Factors[2]
1	Prime	427	7
7	Prime	567	2,3,9
10	2	637	7,13
16	2,4,8	665	5,7,19
19	Prime	703	19
37	Prime	836	2,4,11,19
41	Prime	1,045	5,11,19
42	2,3,7	1,050	2,3,5,7
49	7	1,064	2,4,7,8,19
63	3,7,9	1,078	2,7,11
65	5,13	1,323	3,7,9
133	7,19	1,519	7
152	2,4,8,19	1,666	2,7,17
259	7	1,672	2,4,8,11,19
304	2,4,8,19	1,813	7
308	2,4,7,11	1,976	2,4,8,13,19
413	7	2,100	2,3,5,7

[1]Conductor: Total number of strands
[2]Factors: (Mathematical) Not all-inclusive

Table 2. Cable stranding standards

A side issue: Why do you suppose that the number of strands is almost always an odd — usually prime — number? The answer is below…

Table 2 is a chart of some stranding configurations, and some of their factors. This is hardly all-inclusive, but illustrates the idea.

The construction of stranded wires almost always involves a prime number of strands. [A prime number is defined as one which is divisible only by itself and by 1.] Among larger numbers of strands (more than, say, 250), this may stray from "primeness," but remains an odd number. And in wires having a very great number of strands, (above maybe 1000), there are instances of even-numbered strand counts. These departures from the norm, however, are few: the norm is truly a prime number.

Why?

A solid (1-strand) conductor is the heart of a wire. Stranded wires, then, are surrounded by additional strands, and if all the strands are of the same gauge, six of them fit, ideally, around the center strand. Total: 7. Add another layer (12 will lay best, in minimum space) around those, and it becomes 19.

And so on…

Stranding in larger numbers often entails using bundles ("odd-ly", or "prime-ly" stranded) as if they were individual wires—so that a given high-number stranded construction may become a prime number of prime-numbered "mini" bundles. Confusing? Why not? It's the legacy of a very old business — rope-making.

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