Appendix A. Wires, Sizes and AWG diameters

A.1 AWG and kcmil wires' sizes measurement

The American Wire Gauge (AWG) is used in the United States and in other countries as a standard method of denoting wire diameter. Increasing gauge numbers give decreasing wire diameters; the use of this unit of measure derives from the type of processing carried out on the wire; very fine wire (for example 30 AWG) requires far more passes through the drawing dies than greater wires which, consequently, have a lower AWG identifying them. By definition, 36 AWG has the same value of a wire with 0,005 inches diameter, while 4/0 AWG has the same value of a 0,46 inches diameter. The diameters increase of 0,46/0,005 = 92 times regularly divided in 39 Sizes. Therefore, the diameter of a wire with a x AWG Size is given as follows:

$d_n = 0{,}005 \cdot 92^{\frac{36-x}{39}}$ [inch]
while the Size is
$A_n = \frac{\pi}{4} \cdot d^2_n = 0{,}000019635 \cdot 92^{\frac{36-x}{19{,}5}}$ [inch^2]
for m/0 AWG Size, use x = -(m-1) in the above formulas.

Table A.1a. AWG Size and conversion mm²

AWG	Diameter		Area [mm²]
	[inch]	[mm]	
40	0,0031	0,07987	0,00501
39	0,0035	0,08969	0,00632
38	0,0040	0,1007	0,00797
37	0,0045	0,1131	0,0100
36	0,0050	0,1270	0,0127
35	0,0056	0,1426	0,0160
34	0,0063	0,1601	0,0201
33	0,0071	0,1798	0,0254
32	0,0080	0,2019	0,0320
31	0,0089	0,2268	0,0404
30	0,0100	0,2546	0,0509
29	0,0113	0,2859	0,0642
28	0,0126	0,3211	0,081
27	0,0142	0,3606	0,102
26	0,0159	0,4049	0,129
25	0,0179	0,4547	0,162
24	0,0201	0,5106	0,205
23	0,0226	0,5733	0,258
22	0,0253	0,6438	0,326
21	0,0285	0,7229	0,410
20	0,0320	0,8118	0,518
19	0,0359	0,9116	0,653
18	0,0403	1,024	0,823
17	0,0453	1,150	1,04
16	0,0508	1,291	1,31
15	0,0571	1,450	1,65
14	0,0641	1,628	2,08
13	0,0720	1,828	2,62
12	0,0808	2,053	3,31
11	0,0907	2,305	4,17
10	0,1019	2,588	5,26
9	0,1144	2,906	6,63
8	0,1285	3,264	8,37
7	0,1443	3,665	10,5
6	0,1620	4,115	13,3
5	0,1819	4,621	16,8
4	0,2043	5,189	21,2
3	0,2294	5,827	26,7
2	0,2576	6,544	33,6
1	0,2893	7,348	42,4
0(1/0)	0,3249	8,251	53,5
00(2/0)	0,3648	9,266	67,4
000(3/0)	0,4096	10,40	85
0000(4/0)	0,4600	11,68	107

AWG	Diameter		Area [mm²]
	[inch]	[mm]	
00000(5/0)	0,5165	13,12	135
000000(6/0)	0,5800	14,73	170

The larger Sizes are given in kcmil according to the following table:

Table A.1b. kcmil Sizes and conversion in mm²

kcmil	Diameter		Area [mm²]
	[inch]	[mm]	
250	0,50	12,7	127
300	0,55	13,9	152
350	0,59	15,0	177
400	0,63	16,1	203
450	0,67	17,0	228
500	0,71	17,9	253
550	0,74	18,8	279
600	0,77	19,7	304
650	0,81	20,5	329
700	0,84	21,3	355
750	0,87	22,0	380
800	0,89	22,7	405
900	0,95	24,1	456
1000	1,00	25,4	507
1200	1,10	27,8	608
1250	1,12	28,4	633
1500	1,22	31,1	760
1750	1,32	33,6	887
2000	1,41	35,9	1010

A.2 Wires according to EN 60228

The EN 60228 "Conductors of insulated cables" standard defines the characteristics of the solid conductors (class 1), stranded conductors (class 2) and flexible conductors (class 5 and 6) as follow.

Solid conductors (class 1)

a) Solid conductors are made of bare or tinned copper.
b) Solid copper conductors shall be of circular cross-section.
c) The resistance of each conductor at 20°C must not exceed the value given in the Table A.2a.

Stranded conductors (class 2)

a) The stranded circular conductors are made of bare or tinned copper.
b) The wires in each conductor must have the same nominal diameter.
c) The number of wires in each conductor shall be not less than the value given in the Table A.2b.
d) The resistance of each conductor at 20°C must not exceed the value given in the Table A.2b.

Flexible conductors (class 5 and 6)

a) The flexible conductors are made of bare or tinned copper.
b) The wires in each conductor must have the same nominal diameter.
c) The diameter of the wires in each conductor must not exceed the value given in the Table A.2c and Table A.2d.
d) The resistance of each conductor at 20°C must not exceed the value given in the Table A.2c and Table A.2d.

Table A.2a. Characteristics of the copper solid conductors, class 1, for the production of cables according to CEI EN 60228:2005

Nominal Size	Maximum resistance of the wire at 20°C [Ω /km]	
	Bare copper	Tinned copper
0,5	36,0	36,7
0,75	24,5	24,8
1,0	18,1	18,2
1,5	12,1	12,2
2,5	7,41	7,56
4	4,61	4,70
6	3,08	3,11
10	1,83	1,84
16	1,15	1,16
25	0,727	-
35	0,524	-
50	0,387	-
70	0,268	-
95	0,193	-
120	0,153	-
150	0,124	-
185	0,101	-
240	0,0775	-
300	0,0620	-
400	0,0465	-

Table A.2b. Characteristics of the copper stranded conductors, class 2, for the production of cables according to CEI EN 60228:2005

Nominal Size [mm²]	Minimum number of wires in the conductor	Maximum resistance of the wire at 20°C [Ω /km]	
		Bare copper	Tinned copper
0,5	7	36,0	36,7
0,75	7	24,5	24,8
1,0	7	18,1	18,2
1,5	7	12,1	12,2
2,5	7	7,41	7,56
4	7	4,61	4,70
6	7	3,08	3,11
10	7	1,83	1,84
16	7	1,15	1,16
25	7	0,727	0,734
35	7	0,524	0,529
50	19	0,387	0,391
70	19	0,268	0,270
95	19	0,193	0,195
120	37	0,153	0,154
150	37	0,124	0,126
185	37	0,0991	0,100
240	37	0,0754	0,0762
300	61	0,0601	0,0607
400	61	0,0470	0,0475
500	61	0,0366	0,0369
630	91	0,0283	0,0286
800	91	0,0221	0,0224
1000	91	0,0176	0,0177

Table A.2c. Characteristics of the copper flexible conductors, class 5, for the production of cables according to CEI EN 60228:2005

Nominal Size [mm²]	Maximum diameter of the wires in conductor	Maximum resistance of the wire at 20°C [Ω /km]	
		Bare copper	Tinned copper
0,5	0,21	39,0	40,1
0,75	0,21	26,0	26,7
1,0	0,21	19,5	20,0
1,5	0,26	13,3	13,7
2,5	0,26	7,98	8,21
4	0,31	4,95	5,09
6	0,31	3,30	3,39
10	0,41	1,91	1,95
16	0,41	1,21	1,24
25	0,41	0,780	0,795
35	0,41	0,554	0,565
50	0,41	0,386	0,393
70	0,51	0,272	0,277
95	0,51	0,206	0,210
120	0,51	0,161	0,164
150	0,51	0,129	0,132
185	0,51	0,106	0,108
240	0,51	0,0801	0,0817
300	0,51	0,0641	0,0654
400	0,51	0,0486	0,0495
500	0,61	0,0384	0,0391
630	0,61	0,0287	0,0292

Table A.2d. Characteristics of the copper flexible conductors, class 6, for the production of cables according to CEI EN 60228:2005

Nominal Size [mm²]	Maximum diameter of the wires in conductor [mm]	Maximum resistance of the wire at 20°C [Ω /km]	
		Bare copper	Tinned copper
0,5	0,16	39,0	40,1
0,75	0,16	26,0	26,7
1,0	0,16	19,5	20,0
1,5	0,16	13,3	13,7
2,5	0,16	7,98	8,21
4	0,16	4,95	5,09
6	0,21	3,30	3,39
10	0,21	1,91	1,95
16	0,21	1,21	1,24
25	0,21	0,780	0,795
35	0,21	0,554	0,565
50	0,31	0,386	0,393
70	0,31	0,272	0,277
95	0,31	0,206	0,210
120	0,31	0,161	0,164
150	0,31	0,129	0,132
185	0,41	0,106	0,108
240	0,41	0,0801	0,0817
300	0,41	0,0641	0,0654

A.3 Wires, correlations between AWG and IEC Sizes

Table A.3. Correlation between mm2 (IEC) and AWG cable Sizes

Sizes		Equivalent area [mm²]		
[mm²]	[AWG]	[mm²]	[inch²]	[kcmil]
0,2		0,196	0,000304	387
	24	0,205	0,000317	404
0,3		0,283	0,000438	558
	22	0,324	0,000504	640
0,5		0,5	0,000775	987
	20	0,519	0,000802	1020
0,75		0,75	0,001162	1480
	18	0,823	0,001272	1620
1		1	0,00155	1973
	16	1,31	0,002026	2580
1,5		1,5	0,002325	2960
	14	2,08	0,003228	4110
2,5		2,5	0,003875	4934
	12	3,31	0,005129	6530
4		4	0,0062	7894
	10	5,26	0,008152	10380
6		6	0,0092	11841
	8	8,37	0,012967	16510
10		10	0,0155	19735
	6	13,3	0,02061	26240
16		16	0,0248	31576
	4	21,1	0,03278	41641
25		25	0,0388	49338
	2	33,6	0,0521	66310
35		35	0,0542	69073
	1	42,4	0,0657	83677
50		47	0,0728	92756

Example
A 10 mm² wire can be used as an 8 AWG wire because its size is 10 mm² > 8,37 mm² .
On the contrary, a 18 AWG wire cannot be used as a 1 mm² wire because its equivalent size is 0,823 mm² < 1 mm².

A.4 Minimum cross-Sizeal areas of copper conductors according to EN 60204-1

Table A.4. Minimum cross-Sizeal areas of copper conductors by application according to IEC 60204-1:2018

Location	Application	Minimum cross-Sizeal area [mm²] by type of cable				
		Single core		Multicore		
		Flexible Calss 5 or 6	Solid (Class 1) or stranded (Class 2)	Two cores, shielded	Two cores, not shielded	Three or more cores, shielded or not
Wiring outside protecting enclosures	Power circuits, fixed	1,0	1,5	0,75	0,75	0,75
	Power circuits, subjected to frequent movements	1,0	-	0,75	0,75	0,75
	Control circuits	1,0	1,0	0,2	0,5	0,2
	Data communication	-	-	-	-	0,08
Wiring inside enclosures	Power circuits (connections and moved)	0,75	0,75	0,75	0,75	0,75
	Control circuits	0,2	0,2	0,2	0,2	0,2
	Data communication	-	-	-	-	0,08