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TECHNICAL REPORT

RAPPORT TECHNIQUE

Conductors of insulated cables – Data for AWG and KCMIL sizes

Âmes des câbles isolés – Informations relatives aux sections exprimées en AWG et KCMIL

IEC/TR 62602:2009

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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IEC/TR 62602, which is a technical report, has been prepared by IEC technical committee 20: Electric cables.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
20/1048/DTR	20/1061/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Conductors described in IEC 60228 [1][1] are specified in metric sizes. North America and certain other regions at present use conductor sizes and characteristics according to the American Wire Gauge (AWG) system, and kcmil for larger sizes. The use of these sizes is currently prescribed across North America and elsewhere for installations by sub-national regulations. IEC TC 20 cable product standards do not prescribe cables with AWG/kcmil conductors.

IEC TC 20 recognizes the need to produce a single, harmonized standard for conductors that is truly international. Harmonization, in this respect, is understood as the merging of AWG-based and metric-based sizes to produce one rationalized range of conductor sizes for power cables. TC 20 also recognizes that the development of such a harmonized standard is a long-term project.

A three-stage approach, which will culminate in a single International Standard for conductors, has been agreed.

Stage one of the approach is to produce a technical report that defines the range of AWG/kcmil sizes that are to be considered in the harmonization process.

Stage two of the process is to develop this technical report by starting the rationalization process. The test methods and requirements in this technical report are to be aligned with those in IEC 60228.

The third and final stage will be to produce a harmonized standard, based on IEC 60228 and the work of the first two stages, with a single, rationalized range of conductor sizes. The present expectation is that the third stage will not be achieved before 2020.

This technical report provides resistance and dimensional details for AWG and kcmil sizes as well as giving approximate equivalent metric nominal cross-sectional areas.

The tabulated values of resistance given in this technical report are for single-core cables. Factors are given to determine the maximum resistance for multi-core cables. The alignment of single-core and multi-core cable conductor resistance is to be considered in stage two.

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1 Figures in square brackets refer to the bibliography.

CONDUCTORS OF INSULATED CABLES – DATA FOR AWG AND KCMIL SIZES

1 Scope

IEC/TR 62602, which is a technical report, specifies the nominal cross-sectional areas, in the range 20 AWG to 2 000 kcmil (0,52 mm^2 to 1 010 mm^2), for conductors in electric power cables and cords for a wide range of types. Requirements for numbers and sizes of wires and resistance values are also included. These conductors include solid and stranded copper, aluminium and aluminium alloy conductors in cables for fixed installations and flexible copper conductors.

This technical report is not intended to apply to conductors designed for use in cables intended for telecommunication or data transmission, winding wires or similar products.

Unless indicated to the contrary in a particular clause, this technical report relates to conductors in finished cables and not to conductors made or supplied for inclusion into a cable.

The annexes give supplementary information covering measurement of resistance (Annex A), temperature correction factors for resistance measurement (Annex B) and dimensional limits of circular conductors (Annex C).

2 Terms and definitions

For the purposes of this document, the following definitions apply.

2.1
metal-coated
coated with a thin layer of suitable metal, such as tin or tin alloy

2.2
nominal cross-sectional area
value that identifies a particular size of conductor but is not subject to direct measurement

NOTE Each particular size of conductor in this technical report is required to meet a maximum resistance value.

3 Classification

The conductors have been divided into four classes, 1, 2, 5 and 6. Those in Classes 1 and 2 are intended for use in cables for fixed installations. Classes 5 and 6 are intended for use in flexible cables and cords but may also be used for fixed installations:

– Class 1: solid conductors;
– Class 2: stranded conductors;
– Class 5: flexible conductors;
– Class 6: flexible conductors which are more flexible than Class 5.

4 Materials

4.1 General

The conductors consist of one of the following:

- plain or metal-coated annealed copper;
- aluminium or aluminium alloy.

4.2 Solid aluminium conductors

Circular and shaped solid aluminium conductors are made from aluminium such that the tensile strength of the completed conductor is within the following limits:

Nominal cross-sectional area mm^2	**Tensile strength** N/mm^2
≤13	110 to 165
21 and 34	60 to 130
42	60 to 110
54 and above	60 to 90

NOTE The values given above are not applicable to aluminium alloy conductors.

4.3 Circular and shaped stranded aluminium conductors

Stranded aluminium conductors are made from aluminium such that the tensile strength of the individual wires is within the following limits:

Nominal cross-sectional area mm^2	**Tensile strength** N/mm^2
≤13	Up to 200
21 and above	125 to 205

NOTE 1 The values given above are not applicable to aluminium alloy conductors.

NOTE 2 This data can only be checked on wires taken before stranding and not on wires taken from a stranded conductor.

5 Solid conductors and stranded conductors

5.1 Solid conductors (Class 1)

5.1.1 Construction

a) Solid conductors (Class 1) consist of one of the materials specified in Clause 4.

b) Solid copper conductors are of circular cross-section.

NOTE Solid copper conductors having nominal cross-sectional areas of 21 mm^2 and above are for particular types of cable, e.g. mineral insulated, and not for general purposes.

c) Solid aluminium and solid aluminium alloy conductors of sizes 3,3 mm^2 to 34 mm^2 are of circular cross-section. Larger sizes are of circular cross-section for single-core cables and may be of either circular or shaped cross-section for multi-core cables.

5.1.2 Resistance

The resistance of each conductor at 20 °C, when determined in accordance with Clause 7, does not exceed the appropriate maximum value given in Table 1.

NOTE For solid aluminium alloy conductors, having the same nominal cross-sectional area as an aluminium conductor, the resistance value given in Table 1 should be multiplied by a factor of 1,162, unless otherwise agreed between the manufacturer and the purchaser.

5.2 Stranded circular non-compacted conductors (Class 2)

5.2.1 Construction

a) Stranded circular non-compacted conductors (Class 2) consist of one of the materials specified in Clause 4.

b) The wires in each conductor all have the same nominal diameter.

c) The number of wires in each conductor is not less than the appropriate minimum number given in Table 2.

5.2.2 Resistance

The resistance of each conductor at 20 °C, when determined in accordance with Clause 7, does not exceed the appropriate maximum value given in Table 2.

5.3 Stranded compacted circular conductors and stranded shaped conductors (Class 2)

5.3.1 Construction

a) Stranded compacted circular conductors and stranded shaped conductors (Class 2) consist of one of the materials specified in Clause 4. Stranded shaped copper, aluminium or aluminium alloy conductors have a nominal cross-sectional area of not less than 67 mm^2.

b) The ratio of the diameters of two different wires in the same conductor does not exceed 2.

c) The number of wires in each conductor is not less than the appropriate minimum number given in Table 2.

NOTE This requirement applies to conductors made with wires of circular cross-section before compaction and not to conductors made with pre-shaped wires.

5.3.2 Resistance

The resistance of each conductor at 20 °C, when determined in accordance with Clause 7, does not exceed the appropriate value given in Table 2.

6 Flexible conductors (Classes 5 and 6)

6.1 Construction

a) Flexible conductors (Classes 5 and 6) consist of plain or metal-coated annealed copper.

b) The wires in each conductor have the same nominal diameter.

c) The diameter of the wires in each conductor does not exceed the appropriate maximum value given in Tables 3 or 4.

6.2 Resistance

The resistance of each conductor at 20 °C, when determined in accordance with Clause 7, does not exceed the appropriate maximum value given in Tables 3 or 4.

7 Compliance with Clauses 5 and 6

Compliance with the requirements of 5.1.1, 5.2.1, 5.3.1 and 6.1 is checked on the completed cable by inspection and measurement, where practicable.

Compliance with the requirements for resistance given in 5.1.2, 5.2.2, 5.3.2 and 6.2 is checked by measurement in accordance with Annex A and corrected for temperature by the factors in Table A.1.

Table 1 – Class 1 solid conductors for single-core and multi-core cables [2]

1	2	3	4	5
Nominal cross-sectional area	Size	Maximum resistance of single-core conductors at 20 °C [a]		
		Circular, annealed copper conductors		Aluminium and aluminium alloy conductors, circular or shaped [d]
		Plain	Metal-coated	
mm^2	AWG	Ω/km	Ω/km	Ω/km
0,52	20	33,9	35,2	-
0,82	18	21,4	22,2	-
1,3	16	13,5	14,0	-
2,1	14	8,45	8,78	-
3,3	12	5,31	5,53	8,71 [b]
5,3	10	3,34	3,48	5,48 [b]
8,4	8	2,10	2,16	3,45 [b]
13	6	1,32	1,36	2,17 [b]
21	4	0,832 [c]	0,856 [c]	1,36 [b]
34	2	0,523 [c]	0,538 [c]	0,857 [b]
42	1	0,415 [c]	0,427 [c]	0,680
54	1/0	0,329 [c]	0,337 [c]	0,539
67	2/0	0,261 [c]	0,267 [c]	0,428
85	3/0	0,207 [c]	0,212 [c]	0,339
107	4/0	0,164 [c]	0,168 [c]	0,269

[a] Resistance factors for multi-core cables:

– Insulated conductors cabled in one layer — Table 1 values × 1,02;

– Insulated conductors cabled in more than one layer — Table 1 values × 1,03; or

– Insulated conductors cabled as an assembly of other pre-cabled units — Table 1 values × 1,04.

[b] Aluminium conductors to 34 mm^2 circular only . See 5.1.1.c)

[c] See note to 5.1.1.b)

[d] See note to 5.1.2

2 [2] UL 1581 May 6, 2003 – Table 30.1 & 30.2

Table 2 – Class 2 stranded conductors for single-core and multi-core cables [3]

1	2	3	4	5	6	7	8	9	10	11	12
Nominal cross sectional area			Minimum number of wires in the conductor						Maximum resistance of single-core conductors at 20 °C [a]		
	Size/cross-sectional area		Circular		Circular compacted		Shaped		Annealed copper conductor		Aluminium or aluminium alloy conductor
			Cu	Al	Cu	Al	Cu	Al	Plain wires	Metal-coated wires	
mm^2	AWG	kcmil							Ω/km	Ω/km	Ω/km
0,52	20		7	-	-	-	-	-	34,6	36,7	-
0,82	18		7	-	-	-	-	-	21,8	23,2	-
1,3	16		7	-	-	-	-	-	13,7	14,6	-
2,1	14		7	-	-	-	-	-	8,62	8,96	-
3,3	12		7	7	-	-	-	-	5,43	5,64	8,88
5,3	10		7	7	-	-	-	-	3,41	3,55	5,59
8,4	8		7	7	7	7	-	-	2,14	2,23	3,52
13	6		7	7	7	7	-	-	1,35	1,40	2,21
21	4		7	7	7	7	-	-	0,848	0,882	1,39
34	2		7	7	7	7	-	-	0,534	0,555	0,875
42	1		19	19	18	18	-	-	0,423	0,440	0,693
54	1/0		19	19	18	18	-	-	0,335	0,349	0,550
67	2/0		19	19	18	18	15	15	0,266	0,276	0,436
85	3/0		19	19	18	18	15	15	0,211	0,219	0,346
107	4/0		19	19	18	18	15	15	0,167	0,172	0,274
127		250	37	37	35	35	28	28	0,142	0,147	0,232
177		350	37	37	35	35	28	28	0,101	0,105	0,166
253		500	37	37	35	35	28	28	0,070 8	0,072 9	0,116
380		750	61	61	58	58	47	47	0,047 2	0,048 6	0,077 4
507		1 000	61	61	58	58	47	47	0,035 4	0,036 4	0,058 0
633		1 250	91	91	91	-	-	-	0,028 3	0,029 2	0,046 4
760		1 500	91	91	91	-	-	-	0,023 6	0,024 3	0,038 7
887		1 750	91	91	91	-	-	-	0,020 2	0,020 8	0,033 2
1 014		2 000	127	127	127	-	-	-	0,017 7	0,018 2	0,029 0

[a] Resistance factors for multi-core cables:

– Insulated conductors cabled in one layer — Table 2 values × 1,02;

– Insulated conductors cabled in more than one layer — Table 2 values × 1,03; or

– Insulated conductors cabled as an assembly of other pre-cabled units — Table 2 values × 1,04

3 [2] Resistance UL 1581 May 6, 2003 – Table 30.3 and 30.4 Class B

Strand – Circular ASTM B8 (Cu) B231 (Al) B801 (ACM Al), Combination Unilay ASTM B787 (Cu) B786 (Al), Compact ASTM B496 (Cu) B400 (Al)

Table 3 – Class 5 flexible copper conductors for single core and multi-core cables [4]

1	2	3	4	5	6
Nominal cross-sectional area	**Size/cross-sectional area**		**Maximum diameter of wires in conductor**	**Maximum resistance of single-core conductors at 20 °C [a]**	
				Plain wires	**Metal-coated wires**
mm^2	AWG	kcmil	mm	Ω/km	Ω/km
2,1	14		0,24	8,70	9,24
3,3	12		0,30	5,48	5,81
5,3	10		0,38	3,45	3,66
8,4	8		0,29	2,18	2,33
13	6		0,37	1,38	1,46
21	4		0,46	0,865	0,918
27	3		0,52	0,686	0,728
34	2		0,42	0,547	0,580
42	1		0,47	0,434	0,460
54	1/0		0,52	0,344	0,357
67	2/0		0,59	0,272	0,284
85	3/0		0,66	0,216	0,224
107	4/0		0,74	0,172	0,180
127		250	0,62	0,146	0,152
177		350	0,74	0,104	0,108
253		500	0,88	0,072 9	0,075 8
380		750	0,84	0,049 1	0,051 0
507		1 000	0,97	0,036 8	0,038 2
633		1 250	1,08	0,029 5	0,030 6

[a] Resistance factors for multi-core cables:

– insulated conductors cabled in one layer — Table 3 values × 1,02;

– insulated conductors cabled in more than one layer — Table 3 values × 1,03; or

– insulated conductors cabled as an assembly of other pre-cabled units — Table 3 values × 1,04

4 [2] Resistance UL 1581 May 6, 2003 – Table 30.7 ASTM Class G (14 AWG-10 AWG)
Resistance UL 1581 May 6, 2003 – Table 30.8 ASTM Class H (8 AWG-1250 kcmil)
Max Wire Diameter ASTM B 173 (Nom + 0,01 mm)