

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Radio frequency cables –
Part 0-1: Guidelines to the design of detail specifications – Coaxial cables**

**Câbles pour fréquences radioélectriques –
Partie 0-1: Lignes directrices pour la conception des spécifications particulières
– Câbles coaxiaux**



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NORME INTERNATIONALE

Radio frequency cables – **STANDARD PREVIEW**
Part 0-1: Guidelines to the design of detail specifications – Coaxial cables
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Partie 0-1: Lignes directrices pour la conception des spécifications particulières
– Câbles coaxiaux
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RADIO FREQUENCY CABLES –

Part 0-1: Guidelines to the design of detail specifications –
Coaxial cables

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International standard IEC 60096-0-1 has been prepared by subcommittee 46A: Coaxial cables, of IEC technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

This third edition cancels and replaces the second edition published in 1990 and its Amendment 1 (2000). It constitutes a technical revision.

The significant changes with respect to the previous edition are as follows:

- tables of material constants and factors and have been updated, different equations have been updated and corrected;
- a subclause dealing with the calculation of "Current carrying capacity of coaxial cables" has been added as Subclause 7.7.

The text of this standard is based on the following documents:

FDIS	Report on voting
46A/1043/FDIS	46A/1064/RVD

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

A list of all the parts in the IEC 60096 series, published under the general title *Radio frequency cables*, can be found on the IEC website.

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 stability 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

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RADIO FREQUENCY CABLES –

Part 0-1: Guidelines to the design of detail specifications – Coaxial cables

1 Scope

This part of IEC 60096 provides guidance for the design of radio frequency coaxial cables with braid, metallic tapes or tubular outer conductors.

2 Normative references

Void.

3 Symbols and numbering

3.1 Register of symbols used

Symbol	Designation	Unit
α	Total attenuation per unit length, 20 °C	dB/100 m
α_T	Total attenuation per unit length, $T \neq 20$ °C	dB/100 m
α_x	Attenuation due to element x, 20 °C	dB/100 m
β_x	Braid angle of element x	° (degree)
γ_x	Density of the material of element x	g/cm ³
δ_x	Loss angle of the material of element x	rad
ϵ_x	Relative dielectric permittivity of the material of element x	–
χ_x	Conductivity of the material of element x, 20 °C	m/Ωmm ²
σ_x	Thermal resistivity of the material of element x	K·m/W
B_x	Braid coverage concerning element x	–
c_0	Velocity of propagation in free space	m/s
C	Dielectric diameter	mm
C_x	Capacitance of element x, per unit length	pF/m
d_x	Diameter of individual wires of element x	mm
D_x	Outer diameter of element x	mm
D_{xe}	Electrical effective diameter of element x	mm
D_{xm}	Mean diameter of element x	mm
D	Sheath diameter	mm
D_s	Outer conductor diameter	mm
d	Center conductor diameter	mm
E_2	Maximum permissible voltage gradient of dielectric (peak value)	kV/mm
ϵ	Surface emissivity (sheathed=0,95, bare=0,35)	
f	Frequency	MHz
h_x	Coating thickness concerning element x	mm
I	Current carrying capacity (Amperes)	
k_x, k_{xy}	Calculation factors according to Tables 1 and 2	–
L_x	Braid lay length concerning element x	mm

Symbol	Designation	Unit
\ln	Natural logarithm	
m	Total weight of cable per unit length.....	g/m
m_x	Weight of element x	g/m
N_1	Number of stranded wires of inner conductors	–
N_x	Number of wires to each spindle concerning braid x.....	–
n	Number of cables	
n_x	Number of spindles in the braid concerning element x	–
P_{40}	Maximum permissible input power, ambient temperature 40 °C.....	W
P_i	Thermal resistivity of the dielectric material, Typically = 13,0 K·m/W for both foam, disc and air dielectrics	
P_j	Thermal resistivity of the sheath material, Typically = 3,5 K·m/W for polyethylene Typically = 7,0 K·m/W for polyvinylchloride (PVC) sheaths	
P_T	Maximum permissible input power, ambient temperature $T \neq 40$ °C...	W
P_d	Maximum permissible dissipation power per unit length	W/m
q_x	Filling factor of braid concerning element x	–
R_x	DC resistance of conductive element x, per unit length	Ω /m
	and insulation resistance of insulating element x respectively	M Ω ·km
R_{ic}	Inner conductor resistance	Ω /m at t_a
R_{ictc}	Inner conductor resistance at conductor operating temperature (t_c)	
R_{oc}	Outer conductor resistance	Ω /m at t_a
R_{octc}	Outer conductor resistance at conductor operating temperature (t_c)	
R_{eoc}	Increase in R_{ic} due to effect of outer conductor	
R_{th}	Total thermal resistance of circuit	K.m/W
R_j	Thermal resistance of dielectric	K.m/W
R_j	Thermal resistance of sheath	K.m/W
s_x	Nominal thickness of element x.....	mm
$s_{x\min.}$	Minimal thickness of element x	mm
T_x	Temperature of element x	°C
T_a	Ambient temperature.....	°C
t_c	Conductor operating temperature	°C
t_a	Ambient temperature	°C
t_s	Cable surface temperature	°C
U_t	Test voltage (40 Hz - 60 Hz), rounded r.m.s. value	kV
U_{tc}	Test voltage (40 Hz - 60 Hz), rounded r.m.s. value	kV
U_d	Discharge test voltage, r.m.s. value	kV
U_o	Maximum permissible operating voltage, rounded r.m.s. value	kV
U_{oc}	Maximum permissible operating voltage, calculated r.m.s. value	kV
v_r	Velocity ratio.....	–
z_o	Characteristic impedance, nominal value	Ω

3.2 Numbering of construction elements

Numbering of construction elements in the following tables are as follows:

- 1 Inner conductor
 - 2 Dielectric
 - 3 Outer conductor
 - 4 Sheath
 - 5 Medium between outer conductor and screen
 - 6 Screen
 - 7 Medium between first and second screen
 - 8 Second screen
- etc.

Examples of use of k_x factor are given in Table 1.

Table 1 – Example of use of k_x factor

Symbol	Designation	Unit
k_2	Factor dependent on inner conductor concerning the voltage gradient in the dielectric	–
k_4	Thermal dissipation constant of sheath surface in air	W/m ² K ^{1,25}

Examples of use of k_{xy} factor are given in Table 2.

Table 2 – Example of use of k_{xy} factor

Factor	Construction element concerned			
	1	3	6	8
Coating factor	k_{1c}	k_{3c}		
Stranding or braiding factor:				
– concerning attenuation	k_{1a}	k_{3a}		
– concerning d.c. resistance and weight	k_{1r}	k_{3r}	k_{6r}	k_{8r}
Ratio between overall diameter and diameter of individual wires	k_{1d}			
Effective diameter factor concerning characteristic impedance	k_{1z}			

4 Material constants

4.1 Table of material constants relating to dielectric and sheath and their values for different materials

Material constants relating to dielectric and sheath and their values for different materials are given in Table 3.

Table 3 – Material constants relating to dielectric and sheath and their values for different materials

Symbol	Designation	Unit	Value for a										
			Solid PE	Semi-air-spaced PE	Cellular ^b PE	PTFE	FEP	Cellular ^b FEP	ETFE	PFA	PVC		
ϵ_2	Permittivity of dielectric	–	2,28	1,4	1,3	1,5	1,7	2,1	2,1	1,5	2,6	2,1	
$\tan \delta_2$	Dissipation factor of dielectric	–	$2,5 \times 10^{-4}$	$2,5 \times 10^{-4}$	4×10^{-4}	6×10^{-4}	6×10^{-4}	^c	^f	$1,2 \times 10^{-3}$	^e	^e	
E_2	Maximum permissible voltage gradient of dielectric	kV/mm	11	2	2	2	2	11		2	^e	^e	
γ_2, γ_4	Density of dielectric and sheath	g/cm ³	0,93	0,36	0,28	0,44	0,58	2,2	2,2	0,90	1,7	2,2	1,4 ^b
σ_2, σ_4	Thermal resistivity of dielectric and sheath	K • m/W	3,5	^e	15	9	6	4,4	5,0	^e	4,4	4,5	7,0
T_1	Maximum permissible operating temperature	°C	85/80 ^d	85/80 ^d	70	70	70	250	200 ^g	200 ^g	150 ^g	200 ^g	70

Table 3 (continued)

<p>a</p> <p>PE = polyethylene PTFE = polytetrafluoroethylene FEP = fluorinated ethylene propylene ETFE = ethylenetetrafluoroethylene PFA = perfluoroalkoxyalkane PVC = polyvinylchloride</p>	<p>Typical value(s).</p>	<p>IEC 60096-0-1:2012 https://standards.iteh.ai/catalog/standards/sist/b0f434c0-17d8-4b07-a150-d9cfc0ba0cd5/iec-60096-0-1-2012</p>														
<p>b</p>	<table border="1"> <thead> <tr> <th>Frequency MHz</th> <th>tan δ</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1×10⁻⁴</td> </tr> <tr> <td>101</td> <td>1,5×10⁻⁴</td> </tr> <tr> <td>102</td> <td>2,5×10⁻⁴</td> </tr> <tr> <td>103</td> <td>4,3×10⁻⁴</td> </tr> <tr> <td>104</td> <td>2×10⁻⁴</td> </tr> </tbody> </table>	Frequency MHz	tan δ	1	1×10 ⁻⁴	101	1,5×10 ⁻⁴	102	2,5×10 ⁻⁴	103	4,3×10 ⁻⁴	104	2×10 ⁻⁴	<p>d 85 °C: high density material. 80 °C: other density material.</p>		
Frequency MHz	tan δ															
1	1×10 ⁻⁴															
101	1,5×10 ⁻⁴															
102	2,5×10 ⁻⁴															
103	4,3×10 ⁻⁴															
104	2×10 ⁻⁴															
<p>c</p>	<p>Under consideration</p>	<p>f</p>														
<p>d</p>	<table border="1"> <thead> <tr> <th>Frequency MHz</th> <th>tan δ</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>4×10⁻⁴</td> </tr> <tr> <td>101</td> <td>4×10⁻⁴</td> </tr> <tr> <td>102</td> <td>8×10⁻⁴</td> </tr> <tr> <td>103</td> <td>10×10⁻⁴</td> </tr> <tr> <td>2×103</td> <td>10×10⁻⁴</td> </tr> <tr> <td>104</td> <td>7×10⁻⁴</td> </tr> </tbody> </table>	Frequency MHz	tan δ	1	4×10 ⁻⁴	101	4×10 ⁻⁴	102	8×10 ⁻⁴	103	10×10 ⁻⁴	2×103	10×10 ⁻⁴	104	7×10 ⁻⁴	<p>g In the case of silvered inner and outer conductors only.</p>
Frequency MHz	tan δ															
1	4×10 ⁻⁴															
101	4×10 ⁻⁴															
102	8×10 ⁻⁴															
103	10×10 ⁻⁴															
2×103	10×10 ⁻⁴															
104	7×10 ⁻⁴															

4.2 Tables of material constants relating to conductors

Material constants relating to conductors are given in Tables 4 to 7.

Table 4 – Conductivity (at 20 °C) and density

Conductor	Symbols	Unit	Value	Symbols	Unit	Value
Copper	χ_1, χ_3, χ_6	m/Ωmm ²	58	$\gamma_1, \gamma_3, \gamma_6$	g/cm ³	8,9
Aluminium			35			2,7
Tin			8,3			7,3
Silver			61			10,5
Copper clad steel 30 %			17,4 ^a			8,15
Copper clad steel 40 %			23,2 ^a			8,20

^a For calculation of d.c. resistance only.

Table 5 – Coating factor ^a

Conductor	Symbol	Value
Bare copper wire		1
Silvered copper wire		1
Tinned copper wire	k_{1c} and k_{3c}	Table 6
Copper clad steel wire		Table 7

^a RF resistance of coated wire in relation to bare copper wire, dependent on frequency and coating thickness
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Table 6 – Tinned copper wire

$h_1 \sqrt{f}$ or $h_3 \sqrt{f}$	k_{1c} or k_{3c}
0,01	1,01
0,02	1,03
0,03	1,06
0,04	1,11
0,06	1,25
0,08	1,44
0,10	1,67
0,12	1,91
0,15	2,24
0,18	2,46
0,20	2,60
≥0,25	2,70

Table 7 – Copper clad steel wire

$h_1 \sqrt{f}$	k_{1c}^a
0,005	11,04
0,010	6,06
0,015	4,16
0,020	3,17
0,025	2,57
0,030	2,16
0,035	1,87
0,040	1,65
0,050	1,35
0,060	1,16
0,070	1,04
0,080	1,00

^a Assumptions relating to steel:
 $\chi = 8 \text{ m}/\Omega\text{mm}^2$.
 Relative permeability, $\mu_r = 200$.

4.3 Construction constants

4.3.1 Table of construction constants relating to inner conductor

Construction constants relating to inner conductor are given in Table 8.

Table 8 – Construction constants relating to inner conductor

Symbol	Designation	Value versus number of strands			
		7	12	19	
k_{1r}	Stranding factor for d.c. resistance and weight	1,00	1,03	1,03	1,03
k_{1a}	Stranding factor for attenuation	1,00	1,25	1,25	1,25
k_{1z}	Effective diameter factor	1,00	0,94	0,96	0,98
k_{1d}	Ratio between overall diameter and diameter of individual wires	1,00	3,02	4,16	5,00
k_2	Voltage gradient factor	1,00	0,90	0,90	0,90

4.3.2 Table of construction constants relating to braided outer conductors and screens

Construction constants relating to braided outer conductors and screens are given in Table 9.

Table 9 – Construction constants relating to braided outer conductors and screens

Braid angle $\beta_3; \beta_6$	$\frac{L_3}{D_{3m}}; \frac{L_6}{D_{6m}}$	$k_{3r}; k_{6r}$
20°	8,63	1,06
25°	6,74	1,10
30°	5,44	1,15
35°	4,49	1,22
40°	3,74	1,30
45°	3,14	1,41
Definitions:		
	$k_{3r} = \sqrt{1 + (\pi \cdot D_{3m}/L_3)^2} = \frac{1}{\cos \beta_3}$	
	$k_{6r} = \sqrt{1 + (\pi \cdot D_{6m}/L_6)^2} = \frac{1}{\cos \beta_6}$	

4.4 Table of braid wire dimensions of outer conductor and screen

Braid wire dimensions of outer conductor and screen are given in Table 10.

Table 10 – Braid wire dimensions of outer conductor and screen

Nominal outer diameter of dielectric (D_2) mm	Nominal diameter of braid wire (d_3, d_6) mm	
	Single braid	Double braid
0,87 and 1,5	0,09–0,11	–
2,95, 3,7, 4,8 and 6,4	0,13–0,15	0,13–0,15
7,25, 9,8 and 11,5	0,18–0,20	0,16–0,18
17,3	0,24–0,26	0,18–0,20

4.5 Attenuation factors

Examples of attenuation factors for the calculation of attenuation are given in Table 11.

Table 11 – Factor relating to calculation of attenuation – examples

Symbol	Designation	Feature	Value
k_{1a}	Attenuation due to inner conductor	Solid wire	1,0
		Stranded wire	1,25
k_{1c}		Tinned copper wires	See Table 6
		Copper clad steel wire	See Table 7
k_{3a}	Attenuation due to outer conductor	Tubular outer conductor	1,0
		Braided outer conductor	2,0 ^a
k_{3c}		Braid wires tinned copper	See Table 6
^a Rough approximation (in absence of a reliable theory).			