APPENDIX 2

IEC Std 60364-5-54, 2002

Table 54.3 – Minimum cross-sectional area of protective conductors

Cross-sectional area of line conductor S mm²	Minimum cross-sectional area of the corresponding protective conductor mm²	
	If the protective conductor is of the same material as the line conductor	If the protective conductor is not of the same material as the line conductor
$S \leq 16$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16 [a]	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S}{2}$ [a]	$\frac{k_1}{k_2} \times \frac{S}{2}$

where

k_1 is the value of k for the line conductor, selected from table A.54.1 or from the tables in IEC 60364-4-43, according to the materials of the conductor and insulation;

k_2 is the value of k for the protective conductor, selected from tables A.54.2 to A.54.6 as applicable.

[a] For a PEN conductor, the reduction of the cross-sectional area is permitted only in accordance with the rules for sizing of the neutral conductor (see IEC 60364-5-52).

543.1.2 The cross-sectional areas of protective conductors shall not be less than the value determined either:

- in accordance with IEC 60949;
- or by the following formula applicable only for disconnection times not exceeding 5 s:

$$S = \frac{\sqrt{I^2 t}}{k}$$

where

S is the cross-sectional area, in mm²;

I is the value (r.m.s) in A of prospective fault current for a fault of negligible impedance, which can flow through the protective device (see IEC 60909-0);

t is the operating time of the protective device for automatic disconnection in s;

NOTE 1 Account should be taken of the current-limiting effect of the circuit impedances and the limitation of I^2t of the protective device.

k is the factor dependent on the material of the protective conductor, the insulation and other parts and the initial and the final temperatures (for calculation of k, see annex A).

If application of the formula produces non-standard sizes, conductors of a higher standard cross-sectional area shall be used.

NOTE 2 For limitations of temperatures for installations in potentially explosive atmospheres, see IEC 60079-0.

NOTE 3 As the metallic sheaths of mineral insulated cables according to IEC 60702-1 have an earth fault capacity greater than that of the line conductors, it is not necessary to calculate the cross-sectional area of the metallic sheaths when used as protective conductors.

Annex A
(normative)

Method for deriving the factor k in 543.1.2
(see also IEC 60724 and IEC 60949)

The factor k is determined from the following formula:

$$k = \sqrt{\frac{Q_c(\beta + 20\,°C)}{\rho_{20}} \ln\left(1 + \frac{\theta_f - \theta_i}{\beta + \theta_i}\right)}$$

where

Q_c is the volumetric heat capacity of conductor material (J/°C mm^3) at 20 °C;

β is the reciprocal of temperature coefficient of resistivity at 0 °C for the conductor (°C);

ρ_{20} is the electrical resistivity of conductor material at 20 °C (Ω mm);

θ_i initial temperature of conductor (°C);

θ_f final temperature of conductor (°C).

Table A.54.1 – Value of parameters for different materials

Material	β [a] °C	Q_c [b] J/°C mm^3	ρ_{20} Ω mm	$\sqrt{\frac{Q_c(\beta + 20°C)}{\rho_{20}}}$ A$\sqrt{s}$/mm^2
Copper	234,5	$3{,}45 \times 10^{-3}$	$17{,}241 \times 10^{-6}$	226
Aluminium	228	$2{,}5 \times 10^{-3}$	$28{,}264 \times 10^{-6}$	148
Lead	230	$1{,}45 \times 10^{-3}$	214×10^{-6}	41
Steel	202	$3{,}8 \times 10^{-3}$	138×10^{-6}	78

[a] Values taken from table 1 of IEC 60287-1-1.

[b] Values taken from table E2 of IEC 60853-2.

Table A.54.2 – Values of *k* for insulated protective conductors not incorporated in cables and not bunched with other cables

Conductor insulation	Temperature °C [b]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [c]		
70 °C PVC	30	160/140 [a]	143/133 [a]	95/88 [a]	52/49 [a]
90 °C PVC	30	160/140 [a]	143/133 [a]	95/88 [a]	52/49 [a]
90 °C thermosetting	30	250	176	116	64
60 °C rubber	30	200	159	105	58
85 °C rubber	30	220	166	110	60
Silicone rubber	30	350	201	133	73

[a] The lower value applies to PVC insulated conductors of cross-sectional area greater than 300 mm^2.
[b] Temperature limits for various types of insulation are given in IEC 60724.
[c] For the method of calculating *k*, see the formula at the beginning of this annex.

Table A.54.3 – Values of *k* for bare protective conductors in contact with cable covering but not bunched with other cables

Cable covering	Temperature °C [a]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [b]		
PVC	30	200	159	105	58
Polyethylene	30	150	138	91	50
CSP	30	220	166	110	60

[a] Temperature limits for various types of insulation are given in IEC 60724.
[b] For the method of calculating *k*, see the formula at the beginning of this annex.

Table A.54.4 – Values of *k* for protective conductors as a core incorporated in a cable or bunched with other cables or insulated conductors

Conductor insulation	Temperature °C [b]		Material of conductor		
			Copper	Aluminium	Steel
	Initial	Final	Values for *k* [c]		
70 °C PVC	70	160/140 [a]	115/103 [a]	76/68 [a]	42/37 [a]
90 °C PVC	90	160/140 [a]	100/86 [a]	66/57 [a]	36/31 [a]
90 °C thermosetting	90	250	143	94	52
60 °C rubber	60	200	141	93	51
85 °C rubber	85	220	134	89	48
Silicone rubber	180	350	132	87	47

[a] The lower value applies to PVC insulated conductors of cross-sectional area greater than 300 mm^2.
[b] Temperature limits for various types of insulation are given in IEC 60724.
[c] For the method of calculating *k*, see the formula at the beginning of this annex.