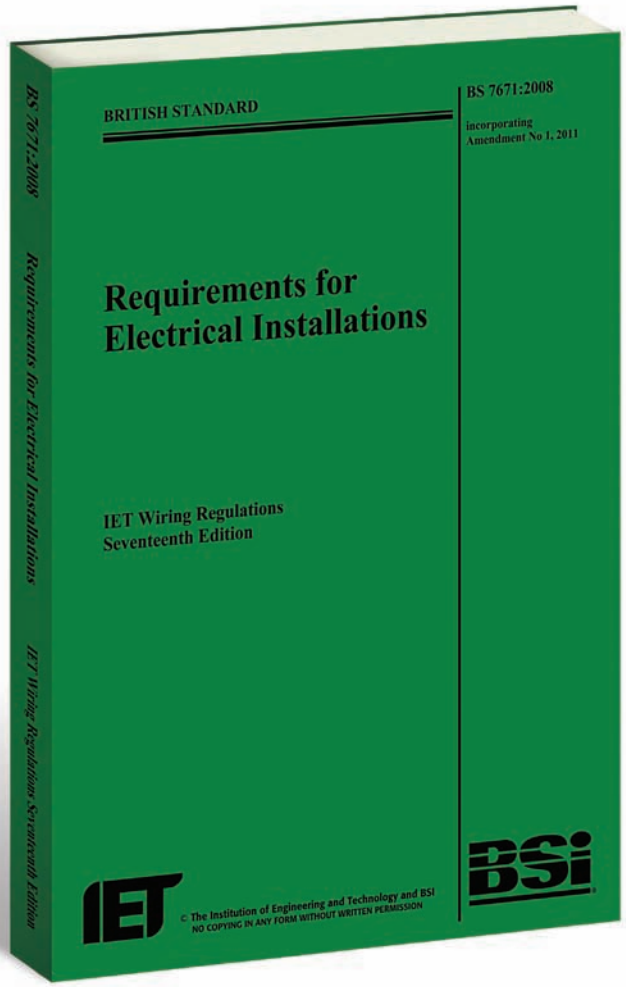
Appendix 4 of Amendment 1 of BS 7671:2008



This article looks at some of the changes introduced into Appendix 4 (current-carrying capacity and voltage drop for cables) by Amendment 1 of the 17th edition of the Wiring Regulations.

By Geoff Cronshaw

Appendix 4 is an informative appendix within BS 7671. The appendix includes tabulated current carrying capacities for some of the most commonly used cables in the electrical installation industry.

These include single and multicore 70 degree thermoplastic and 90 degree thermosetting insulated cables with copper conductors, 70 degree thermoplastic insulated and sheathed flat cable with protective conductor (copper), a range of armoured cables, and mineral insulated cables. Also a range of cables with aluminium conductors.

Tables 4D1A to Tables 4J4A contain the current carrying capacities in amperes for the various types of cable. Each table contains reference methods.

Installation methods and reference methods

The number of installation methods described in Table 4A2 of appendix 4 has been increased to almost 80 in Amendment 1 of the 17th edition compared to just 20 in the16th edition. Although this may appear to make things more complicated, the appendix now embraces installation methods that are used but which were not previously accounted for, including installation methods in building voids, direct in ground, in ducts in the ground, and flat twin and earth cables in thermal insulation.

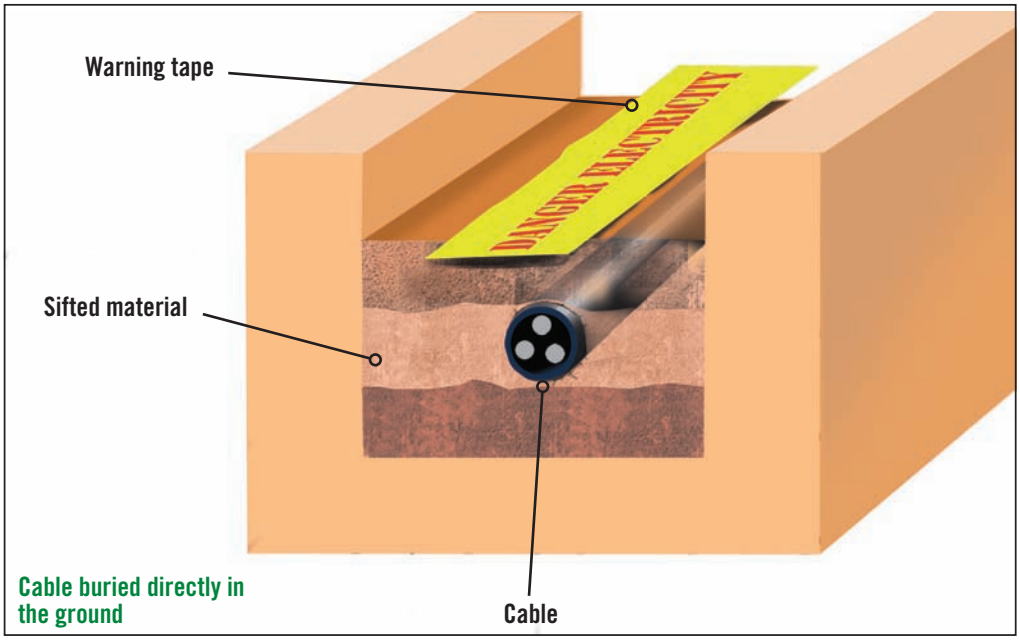
It is impractical to calculate and publish current ratings for every installation method, since many would result in the same current rating. Therefore a suitable (limited) number of current ratings have been calculated which cover all of the installations stated in the Wiring Regulations, and are called reference methods.

All the individually numbered installation methods have a lettered reference method stated against them in Table 4A2, except for flat twin and earth cables which have reference method numbers 100 to 103. There are seven alphabetically lettered reference methods, that is A to G.

The lettered reference methods broadly cover the following areas:

- Reference method A – Enclosed in conduit in thermally insulated walls etc. (Note: The wall consists of an outer weatherproof skin, thermal insulation and an inner skin of wood or wood-like material having a thermal conductance of at least 10 W/m2K. The conduit is fixed so as to be close to, but not necessarily touching, the inner skin. Heat from the cables is assumed to escape through the inner skin only. The conduit can be metal or plastic.)
- Reference method B – Enclosed in conduit on a wall or in trunking etc.
- Reference method C – Clipped direct.
- Reference method D – Direct in the ground or in ducting in the ground.
- Reference method E – Multicore cables in free air or on perforated trays etc. ▶

- Reference method F – Single-core cable touching in free air or on perforated trays etc.
- Reference method G – Single-core cable spaced in free air or on perforated trays etc.



Effective current-carrying capacity

The current-carrying capacity of a cable corresponds to the maximum current that can be carried in specified conditions without the conductors exceeding the permissible limit of steady-state temperature for the type of insulation concerned.

The values of current tabulated represent the effective current-carrying capacity only where no rating factor is applicable.

Otherwise, the current-carrying capacity corresponds to the tabulated value multiplied by the appropriate factor or factors for ambient temperature, grouping and thermal insulation as well as depth of burial and soil thermal resistivity, for buried cables, as applicable. Where harmonic currents are present further factors may need to be applied.

Important: *a rating factor has to be applied where the installation conditions differ from those for which values of current-carrying capacity are tabulated in Tables 4D1A to Tables 4J4A of appendix 4.*

The various rating factors (some of which have been modified by amendment 1) are identified below.

Ca for ambient temperature

Cc for circuits buried in the ground

Cd for depth of burial

Cf for semi-enclosed fuse to BS 3036

Cg for grouping

Ci for thermal insulation

Cs for thermal resistivity of soil.

Cables direct in ground or in ducts in the ground

It is worthwhile highlighting that the amendment 1 of BS 7671:2008 (17th edition) includes references for cables buried in the ground (installation methods 70 to 73). These were introduced in the 17th edition when it was published in 2008 but amendment 1 includes some significant changes.

The current-carrying capacities tabulated for cables in the ground are based upon a soil thermal resistivity of 2.5 K.m/W and are intended to be applied to cables laid in and around buildings, i.e. disturbed soil.

In locations where the effective soil thermal resistivity is higher than 2.5 K.m/W, an appropriate reduction in current-carrying capacity should be made. *Rating factors for soil thermal resistivities other than 2.5* ▶

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◄ *K.m/W are given in Table 4B3* (extract shown right).

It is important to note that the tabulated current-carrying capacities for cables direct in ground or in ducts in the ground, given in appendix 4, are based an ambient ground temperature of 20°C. The factor of 1.45 that is applied in Regulation 433.1.1 when considering overload protection assumes that the tabulated current-carrying capacities are based on an ambient air temperature of 30°C. To achieve the same degree of overload protection when the tabulated current-carrying capacity is based on an ambient temperature of 20°C *where a cable is "in a duct in the ground" or "buried direct" as compared with other installation methods a rating factor of 0.9 is applied as a multiplier to the tabulated current carrying capacity.*

Where cables are at depths other than 0.7 m direct buried or buried in ducts TABLE 4B4 gives rating factors (Cd) which are shown above right.

TABLE 4B3 – Rating factors (C_s) for cables buried direct in the ground or in an underground conduit system to BS EN 50086-2-4 for soil thermal resistivities other than 2.5 K.m/W to be applied to the current-carrying capacities for Reference Method D

Thermal resistivity, K.m/W	0.5	0.8	1	1.2	1.5	2	2.5	3
Rating factor for cables in buried ducts	1.28	1.20	1.18	1.13	1.1	1.05	1	0.96
Rating factor for direct buried cables	1.88	1.62	1.5	1.40	1.28	1.12	1	0.90

NOTE 1: The rating factors given have been averaged over the range of conductor sizes and types of installation included in the relevant tables in this appendix. The overall accuracy of rating factors is within ± 5%.
NOTE 2: Where more precise values are required they may be calculated by methods given in BS 7769 (BS IEC 60287).
NOTE 3: The rating factors are applicable to ducts buried at depths of up to 0.8 m.

TABLE 4B4 – Rating factors (C_d) for depths of laying other than 0.7 m for direct buried cables and cables in buried ducts

Depth of laying, m	Buried direct	In buried ducts
0.5	1.03	1.02
0.7	1.00	1.00
1	0.97	0.98
1.25	0.95	0.96
1.5	0.94	0.95
1.75	0.93	0.94
2	0.92	0.93
2.5	0.90	0.92
3	0.89	0.91

The relevant symbols used in the Regulations are as follows:

Iz the current-carrying capacity of a cable for continuous service, under the particular installation conditions concerned.

It the value of current tabulated in this appendix for the type of cable and installation method concerned, for a single circuit in the ambient temperature stated in the current-carrying capacity tables.

Ib the design current of the circuit, i.e. the current intended to be carried by the circuit in normal service.

In the rated current or current setting of the protective device.

I2 the operating current (i.e. the fusing current or tripping current for the conventional operating time) of the device protecting the circuit against overload.

Section 5 of Appendix 4 gives information on the determination of the size of cable to be used. A part extract from Section 5, left, demonstrates how rating factors are applied. Please refer to the complete appendix for all the essential information including voltage drop. ►

5 DETERMINATION OF THE SIZE OF CABLE TO BE USED

5.1 Where overload protection is afforded by a device listed in Regulation 433.1.100 or a semi-enclosed fuse to BS 3036

5.1.1 For single circuits

(i) Divide the rated current of the protective device (I_n) by any applicable rating factors for ambient temperature (C_a) , soil thermal resistivity (C_s) and depth of burial (C_d) given in Tables 4B1 to 4B4.

For cables installed above ground C_s and $C_d = 1$.

(ii) Then further divide by any applicable rating factor for thermal insulation (C_i).

(iii) Then further divide by the applicable rating factor for the type of protective device or installation condition (C_f, C_c):

$$I_t \geq \frac{I_n}{C_a\, C_s\, C_d\, C_i\, C_f\, C_c}$$

a) Where the protective device is a semi-enclosed fuse to BS 3036, $C_f = 0.725$. Otherwise $C_f = 1$

b) Where the cable installation method is 'in a duct in the ground' or 'buried direct', $C_c = 0.9$. For cables installed above ground $C_c = 1$.

The size of cable to be used is to be such that its tabulated current-carrying capacity (I_t) is not less than the value of rated current of the protective device adjusted as above.

5.1.2 For groups

(i) In addition to the factors given in 5.1.1, divide the rated current of the protective device (I_n) by the applicable rating factor for grouping (C_g) given in Tables 4C1 to 4C6:

$$I_t \geq \frac{I_n}{C_g\, C_a\, C_s\, C_d\, C_i\, C_f\, C_c}$$

Additional installation methods

Amendment 1 of the 17th edition has introduced additional installation methods 117 to 120 for cables enclosed in infloor concrete troughs. An extract of the new installation methods are shown to the right.

Conclusion

Please note this article is only intended as a brief overview of some of the changes introduced into Appendix 4 by amendment 1 of the 17th edition of the wiring regulations.

Circuits must be designed that are fit for purpose and suitable for the load they are intended to supply. They should be correctly designed in accordance with BS 7671.

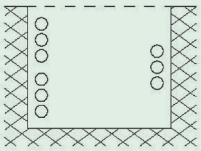
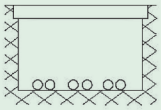
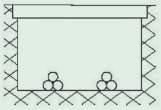
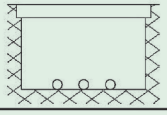
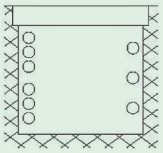
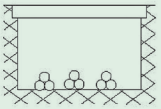
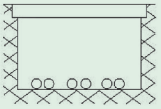
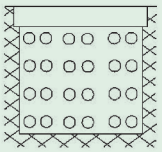
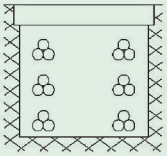
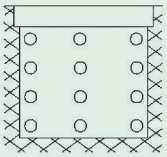
Chapter 43 deals with protection against overcurrent and also thermal constraints, Chapter 42 has requirements for protection against thermal effects, Chapter 41 deals with protection against electric shock and gives the disconnection times that must be met whilst Section 525 deals with voltage drop.

In addition Section 526 and 512.1.5 has requirements for the temperature of conductors connected to equipment terminals. Appendix 4 gives tabulated current carrying capacity and voltage drop for cables.

All these areas need to be taken into account when determining the cable size for a particular circuit. ■

For more information refer to Amendment 1 of BS 7671:2008.

TABLE 4A2 *(continued –*
Installation methods for cables enclosed in infloor concrete troughs)

Installation Method			Reference Method to be used to determine current-carrying capacity
Number	Examples	Description	
117		Cables supported on the wall of an open or ventilated infloor concrete trough with spacing as follows: - Sheathed single-core cables in free air (any supporting metalwork under the cables occupying less than 10% of plan area). - Two or three cables vertically one above the other, minimum distance between cable surfaces equal to the overall cable diameters, distance from the wall not less than ½ the cable diameter. - Two or three cables horizontally with spacing as above	E or F
118	  	Cables in enclosed trench 450 mm wide by 300 mm deep (minimum dimensions) including 100 mm cover - Two to six single–core cables with surfaces separated by a minimum of one cable diameter - One or two groups of three single-core cables in trefoil formation - One to four 2-core cables or one to three cables of 3 or 4 cores with all cables separated by a minimum of 50 mm	E or F using rating factors in Table 4C6
119	  	Cables enclosed in an infloor concrete trough 450 mm wide by 600 mm deep (minimum dimensions) including 100 mm cover. Six to twelve single-core cables arranged in flat groups of two or three on the vertical trench wall with cables separated by one cable diameter and a minimum of 50 mm between groups or two to four groups of three single-core cables in trefoil formation with a minimum of 50 mm between trefoil formations or four to eight 2-core cables or three to six cables of 3 or 4 cores with cables separated by a minimum of 75 mm. All cables spaced at least 25 mm from trench wall.	E or F using rating factors in Table 4C6
120	  	Cables enclosed in an infloor concrete trough 600mm wide by 760 mm deep (minimum dimensions) including 100 mm cover. Twelve to twenty four single-core cables arranged in either flat formation of two or three cables in a group with cables separated by one cable diameter and each cable group separated by a minimum of 50 mm either horizontally or vertically or single-core cables in trefoil formation with each group or trefoil formation separated by a minimum of 50 mm either horizontally or vertically or eight to sixteen 2-core cables or six to twelve cables of 3 or 4 cores with cables separated by a minimum of 75 mm either horizontally or vertically. All cables spaced at least 25 mm from trench wall.	E or F using rating factors in Table 4C6