Short guide to working out cable sizes

In the first of two articles, *Bill Allan* looks at the correct method in cross-sectional work, a job that requires a head for calculations and a steady hand

Ask any electrician about the required cross-sectional areas of cables for standard circuits and the answer you receive will probably be along the lines of: "1mm^2 or 1.5 mm^2 for lighting circuits and 2.5 mm^2 for socket-outlet circuits."

Indeed these are the commonly used rule of thumb sizes.

However, those who undertake electrical installation work need to understand the procedure for selecting the correct cross-sectional area of a cable for a particular use.

It is the intention of this article to explain simply how to select the correct cross-sectional area of cables with particular single-phase loads in mind.

I'll refer to the tables in Appendix 4 of BS 7671, although these tables are reproduced in Appendix 6 of the IEE On Site Guide. We'll assume that the overcurrent protective device will be providing fault current and overload current which is the normal situation.

Calculating the right size

There are five steps to calculating the right size of cable for a particular load. These are as follows:

1 Calculate the design current (Ib). This is the normal current drawn by the load. It is usually determined as follows:

$$Ib = \frac{Watts}{Volts}$$

2 Select the type and current rating of the overcurrent device (I_n).

3 Apply the relevant correction factors to obtain the tabulated current (I_t).
Correction factors are applied to situations which inhibit a cable from dissipating its heat caused by the normal flow of current through it. Therefore, the following correction factors, if applicable, are applied:

Ambient temperature, C_a

This factor is obtained from Table 4C1 (or Table 4C2 if a rewireable fuse to BS 3036 is used) in Appendix 4 of BS 7671.

Grouping, C_g

This factor is found by reference to Table 4B1 in Appendix 4. Table 4B2 is used where mineral insulated cables are installed on perforated cable tray.

Thermal insulation, C_i

Where a cable is in contact with thermal insulation on one side only, the current-carrying capacity of the cable should be calculated using Reference Method 4, which is described in Appendix 4 (Table 4A) of BS 7671.

Where a cable is totally surrounded by thermal insulation for a distance greater than 0.5 metres, the current-carrying capacity should be taken, in the absence of further information, as 0.5 times the current-carrying capacity for that cable when using Installation Method 1 (open and clipped direct).

Where a cable is totally surrounded by thermal insulation for a distance of 0.5 metres or less, Table 52A in BS 7671 gives derating factors which must be applied.

Rewireable fuse (BS 3036) factor, C_r

Where a rewireable fuse to BS 3036 is used, a further correction factor of 0.725 is applied, due to the poor fusing factor of rewireable fuses.

How to apply correction factors

These correction factors are applied as divisors to the nominal current rating of the overcurrent protective device (I_n), to obtain the tabulated current, I_t. For example, in the worst possible situation where all four factors are applied, the formula would look like this:

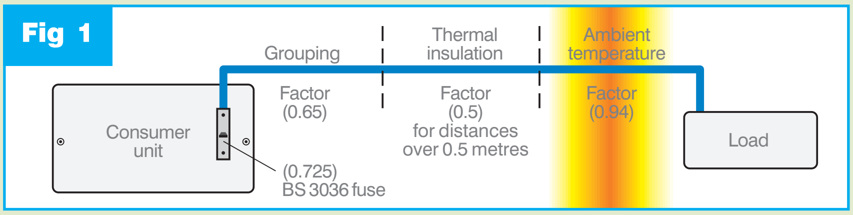
$$I_t \geq \frac{I_n}{C_a \times C_g \times C_i \times C_r}$$

The more correction factors we apply, the larger the value of It will be and hence the larger the size of cable we will require. Consequently, it is advantageous to avoid having to apply correction factors where possible by, such measures as, avoiding grouping of cables and avoiding contact with thermal insulation.

However the formula given above is based on the assumption that the conditions requiring the application of correction factors apply simultaneously to the same part of the cable along its route.

Where particular correction factors are appropriate to different parts of the cable along its route, each part can be treated separately. Alternatively, only the correction factor (or combination of factors) applicable to the worst situation along the cable route can be applied to the whole route. (See Item 6.4 of Appendix 4 in BS 7671)

Fig 1



For example, in Fig 1, a cable which is protected by a BS 3036 rewireable fuse is first grouped together with other cables, then it is totally surrounded by thermal insulation for a distance of more than 0.5 metres. Then finally it is run through an area with a high ambient temperature. As the BS 3036 fuse affects the whole cable run, C_t must be applied. However, there is no need to apply the other three factors as the worst factor alone will be sufficient. Let's take the grouping factor to be 0.65, the thermal insulation factor to be 0.5 and the ambient temperature factor as 0.94, as indicated in Fig 1. In this case, only C_r = 0.725 and C_i = 0.5 need to be applied. The factors for grouping and ambient temperature are 0.65 x 0.94 = 0.61. As the factor for thermal insulation is lower (0.5), this is the only factor used for the conditions along the cable run.

$$I_t \geq \frac{I_n}{C_i \times C_r}$$

4 The current-carrying capacity of the cable (which is termed I_z) is then selected from the appropriate table in Appendix 4 of BS 7671. I_z should be at least equal to or slightly greater than the tabulated current, I_t.

5 Calculate the voltage drop to ensure that it is not excessive. Regulation 525-01-02 states that the voltage drop from the origin of the supply to the furthest point in the installation must not exceed four per cent of the supply voltage when the conductors are carrying full load current. The tables in Appendix 4 have a voltage drop section in which the millivolt per amp per metre (mv/a/m) of a particular cable may be obtained. The voltage drop is calculated from:

Volts drop =

$$\frac{\text{mv/a/m x design current, } I_b \text{ x length of run in metres, L}}{1000}$$

As four per cent of the nominal 230 volts single-phase supply voltage is 9.2 volts, this figure must not be exceeded for single-phase supplies.

Conclusion

If you need some practice in calculating the right size for cables, you might try the examples in the Student Activities section. In the next issue, we'll consider this topic some more. Further information can be obtained from Appendix 4 of BS 7671, and IEE Guidance Note 6, Protection Against Overcurrent. For a more simplified approach, Appendix 6 of the IEE On Site Guide should be consulted.

Worked example

1 A 6kW load is to be supplied at 230 V by a PVC sheathed and insulated twin and cpc copper cable, 8 metres in length. The cable is clipped on the surface through an area with an ambient temperature of 40°C and is grouped with three other cables of similar size and loading. The protection is by means of a BS 3036 fuse. Calculate the minimum cable size required (it is assumed in this example that all the correction factors need to be applied).

Answer

Design current, $I_b = \frac{W}{V} = \frac{6000}{230} = 26$ amps

Size of BS 3036 fuse required = 30 amps (I_n)

Tabulated current, $I_t \geq \frac{I_n}{\text{correction factors}}$

From Table 4C2, $C_a = 0.94$

From Table 4B1, (4 circuits, Method 1) $C_g = 0.65$

Correction factor for BS 3036 fuse = 0.725

$$I_t \geq \frac{I_n}{C_a \times C_g \times C_r}$$

$$\geq \frac{I_n}{0.94 \times 0.65 \times 0.725}$$

$$\geq 67.7 \text{ amps}$$

From Table 4D5A (Reference Method 1, column 4), select 16 mm^2 cable which takes 85 amps.

Check volts drop from Table 4D2B (column 3).

$$\text{volts drop} = \frac{\text{mV/Am} \times I_b \times L}{1000}$$

$$= \frac{2.8 \times 26 \times 8}{1000}$$

$$= 0.58 \text{ volts (satisfactory)}$$