SIZING OF PROTECTIVE CONDUCTORS BY CALCULATION

Regulation Group 543.1 of *BS 7671* requires that a protective conductor other than an protective bonding conductor is sized either by calculation or selection. This Guide covers the sizing of protective conductors by calculation, which uses the adiabatic equation, as explained later. Information on sizing of protective conductors by selection is given in Pocket Guide 14.

A protective conductor must always be sized by calculation where the line conductor has been sized by considerations of short-circuit current and if the earth fault current is expected to be less than the short-circuit current (543.1.1).

MINIMUM PROTECTIVE CONDUCTOR SIZES

Certain lower limits apply to the cross-sectional-area (csa) of the protective conductor. The size of the protective conductor used must not be less than the limiting values given in Regulations 543.1.1 and, where applicable, 544.1.1 as discussed in Pocket Guide 14.

CALCULATING THE SIZE OF THE PROTECTIVE CONDUCTOR

The csa of the protective conductor, where calculated, is to be no less than the value (S) determined using the adiabatic equation (543.1.3).

Where:

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

S is the nominal csa of the protective conductor in mm^2.

I is the value in amperes (rms for AC) of the fault current for a fault of negligible impedance, which can flow through the associated protective device, due account being taken of the current limiting effect of the circuit impedances and the limiting capability (I^2t) of that protective device.

t is the operating time of the disconnecting device in seconds corresponding to the fault current (I) in amperes.

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures of the conductors.

Where a non-standard size is calculated, a conductor having at least the nearest larger standard csa should be used.

Where the protective conductor is common to several circuits, the calculation process should be based on the most onerous values of fault current (I) and operating time (t) (or energy let-through (I^2t)) encountered in each of the circuits (543.1.2).

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DETERMINING THE VALUES OF FAULT CURRENT (*I*) AND TIME (*t*)

The value of fault current (*I*) used in the adiabatic equation is normally determined by calculation, from the following formula:

Where:

$$I = \frac{U_0}{Z_s}$$

I the fault current (*I*) at the furthest point in the circuit.

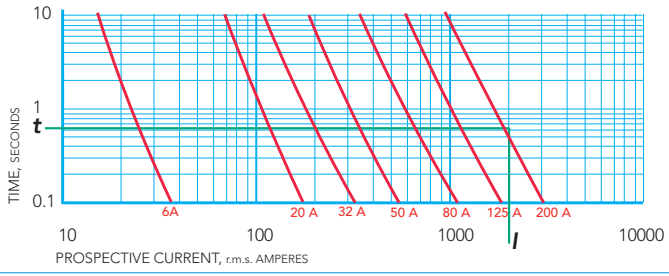
U_0 the nominal voltage.

Z_s the measured value of earth fault loop impedance corrected to allow for the circuit conductors being at their normal operating temperature.

The value of operating time (*t*) for the disconnecting device, for use in the adiabatic equation, can often be found from the time/current characteristic for the device. An example of determining *t* is given below.

FUSES TO *BS 88-2* FUSE SYSTEM E AND G

Example only, do not use for design



It can be seen from the time/current characteristic of the 200 A *BS 88* fuse (above) that, with a fault current (*I*) of 2000 A, the protective device has an operating time (*t*) of 0.55 seconds. However, where the value of *I* is so high that the corresponding value of *t* is not shown in the time/current characteristic for the disconnecting device, the value of energy let-through (I^2t) should be obtained from the device manufacturer and substituted into the adiabatic equation. The use of a value of I^2t obtained from the manufacturer may also be necessary in the following circumstances:

- for operating times (less than 0.1 s) where asymmetry of current is significant, such as for a protective device close to the output terminals of a generator or transformer
- where the protective device is a current limiting circuit-breaker or fuse that will 'cut off' or limit the current during prospective earth fault conditions.

VALUE OF *k* FOR USE IN THE ADIABATIC EQUATION

Values of *k* for protective conductors for use in the adiabatic equation, may be obtained from Tables 54.2, 54.3, 54.4, 54.5 and 54.6 of *BS 7671* extracts from which are reproduced in Pocket Guide 14, for the most common situations.

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