THERMAL CONSTRAINTS (IEE REGULATIONS SECTION 543)

The IEE Regulations require that we either select or check the size of a cpc against Table 54.7 of the Regulations, or calculate its size using an adiabatic equation.

Selection of cpc using Table 54.7

Table 54.7 of the Regulations simply tells us that:

1. For line conductors up to and including 16 mm^2, the cpc should be at least the same size.
2. For sizes between 16 mm^2 and 35 mm^2, the cpc should be at least 16 mm^2.
3. For sizes of line conductor over 35 mm^2, the cpc should be at least half this size.

This is all very well, but for large sizes of line conductor the cpc is also large and hence costly to supply and install. Also, composite cables such as the typical twin with cpc 6242Y type have cpcs smaller than the line conductor and hence do not comply with Table 54.7.

Calculation of cpc using an adiabatic equation

The adiabatic equation

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

enables us to check on a selected size of cable, or on an actual size in a multicore cable. In order to apply the equation we need first to calculate the earth fault current from:

$$I = U_0 / Z_s$$

where U_0 is the nominal line voltage to earth (usually 230 V) and Z_s is the actual earth fault loop impedance. Next we select a k factor from Tables 54.2 to 54.7 of the Regulations, and then determine the disconnection time t from the relevant curve.

For those unfamiliar with such curves, using them may appear a daunting task. A brief explanation may help to dispel any fears. Referring to any of the curves for fuses in Appendix 3 of the IEE Regulations, we can see that the current scale goes from 1 A to 10 000 A, and the time scale from 0.01 s to 10 000 s. One can imagine the difficulty in drawing a scale between 1 A and 10 000 A in divisions of 1 A, and so a logarithmic scale is used. This cramps the large scale into a small area. All the subdivisions between the major divisions increase in equal amounts depending on the major division boundaries; for example, all the subdivisions between 100 and 1000 are in amounts of 100 (Figure 5.7).

Figures 5.8 and 5.9 give the IEE Regulations time/current curves for BS 88 fuses. Referring to the appropriate curve for a 32 A fuse (Figure 5.9), we find that a fault current of 200 A will cause disconnection of the supply in 0.6 s.

Where a value falls between two subdivisions, for example 150 A, an estimate of its position must be made. Remember that even if the scale is not visible, it would be cramped at one end; so 150 A would not fall half-way between 100 A and 200 A (Figure 5.8).

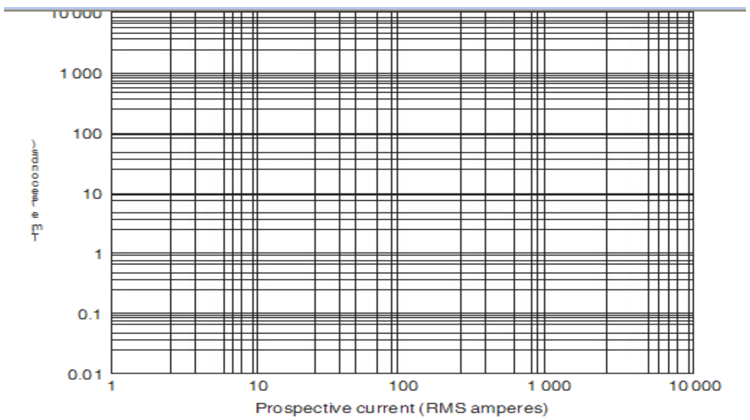


FIGURE 5.7

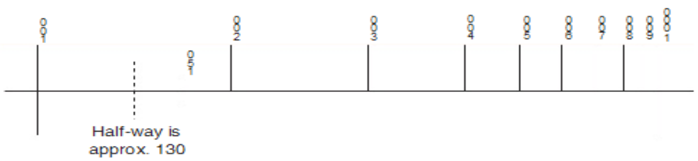


FIGURE 5.8

causes operation of the protective device for disconnection times of 0.1 s, 0.4 s and 5 s.

The IEE Regulations curves for CBs to BS EN 60898 type B and RCBOs are shown in Figure 5.9.

Having found a disconnection time, we can now apply the formula.

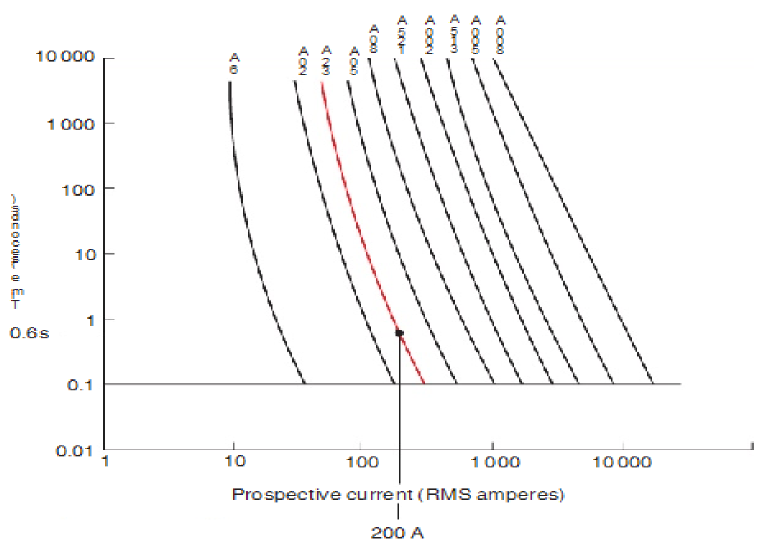


FIGURE 5.9 Time/current characteristics for fuses to BS 88 Part 2. Example for 32 A fuse superimposed.

EXAMPLE OF USE OF THE ADIABATIC EQUATION

Suppose that in a design the protection was by 40 A BS 88 fuse; we had chosen a 4.0 mm^2 copper cpc running with our line conductor; and the loop impedance Z_s was 1.15 Ω. Would the chosen cpc size be large enough to withstand damage in the event of an earth fault? We have:

$$I = U_0/Z_s = 230/1.15 = 200\ \text{A}$$

From the appropriate curve for the 40 A BS 88 fuse (Figure 5.10), we obtain a disconnection time t of 2 s. From Table 54.3 of

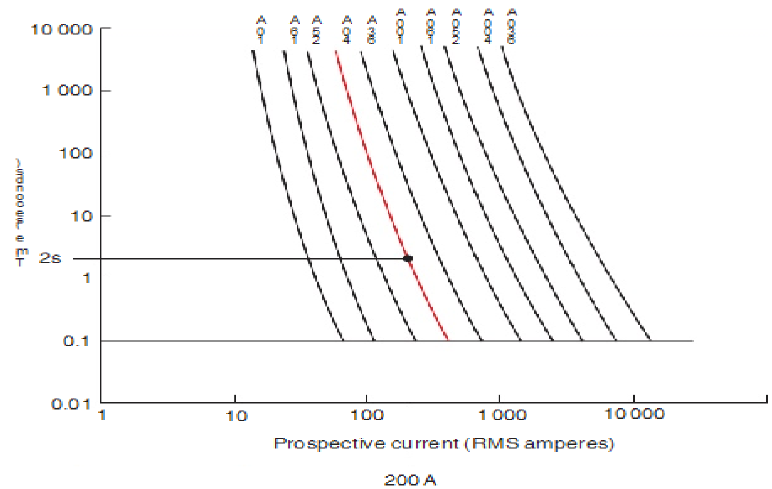


FIGURE 5.10 Time/current characteristics for fuses to BS 88 Part 2. Example for 40 A fuse superimposed.

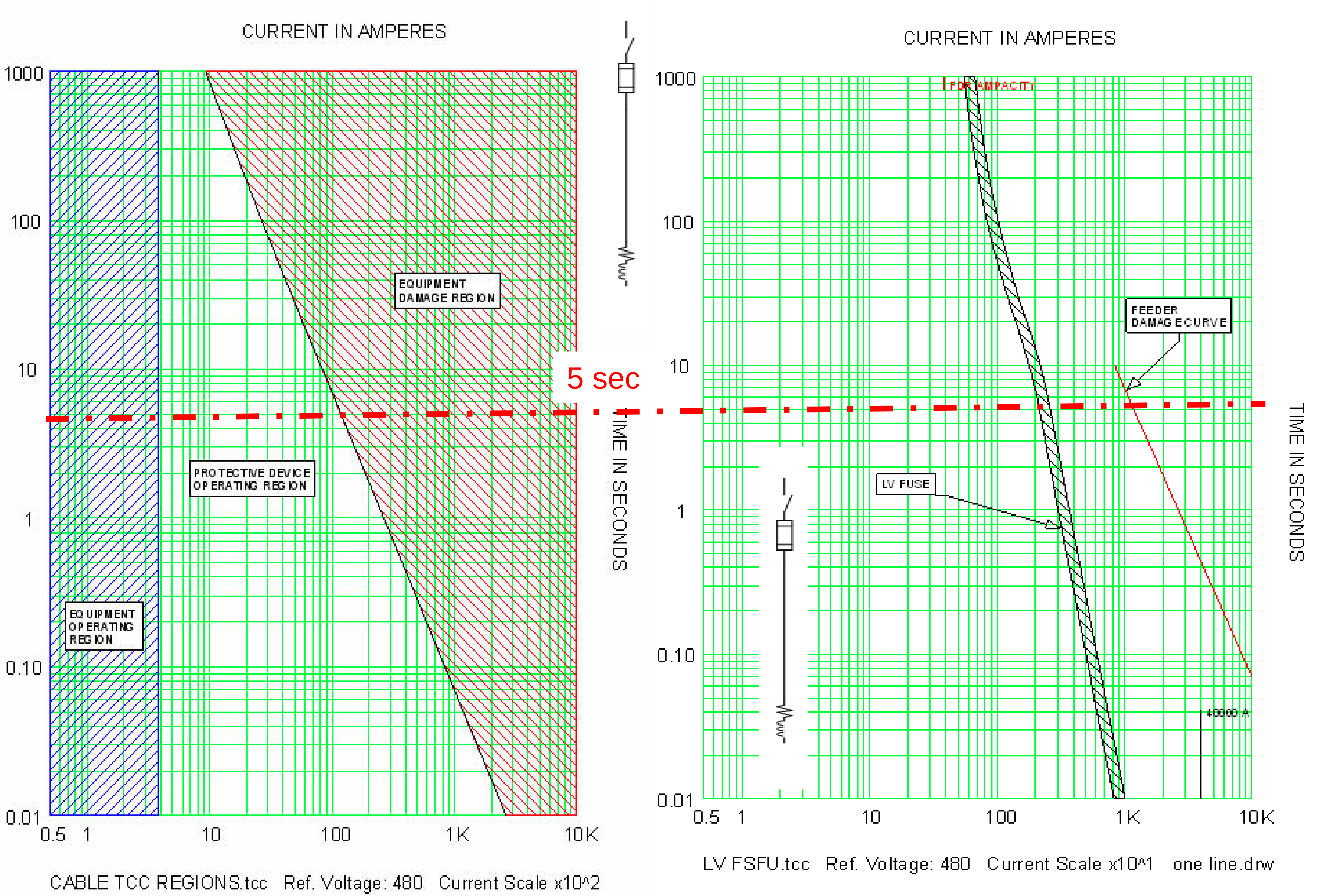
the Regulations, $k = 115$. Therefore the minimum size of cpc is given by:

$$s = \frac{\sqrt{I^2 t}}{k} = \frac{\sqrt{200^2 \times 2}}{115} = 2.46\ \text{mm}^2$$

So our 4.0 mm^2 cpc is acceptable. Beware of thinking that the answer means that we could change the 4.0 mm^2 for a 2.5 mm^2. If we did, the loop impedance would be different and hence I and t would change; the answer for s would probably tell us to use a 4.0 mm^2.

In the example shown, 's' is merely a check on the actual size chosen.

SOURCE: SKM


CURRENT IN AMPERES
1000
100
10
1
0.10
0.01
0.5
1
10
100
1K
10K
EQUIPMENT DAMAGE REGION
PROTECTIVE DEVICE OPERATING REGION
EQUIPMENT OPERATING REGION
TIME IN SECONDS
CABLE TCC REGIONS.tcc Ref. Voltage: 480 Current Scale x10^2
5 sec
CURRENT IN AMPERES
FDR AMPACITY
FEEDER DAMAGE CURVE
LV FUSE
TIME IN SECONDS
LV FSFU.tcc Ref. Voltage: 480 Current Scale x10^1 one line.drw