203: Electrical installations technology  
**Handout 21: Cable selection**

**Learning outcome**

The learner will:

1. know wiring systems of electrical installations.

**Assessment criteria**

The learner can:

3.3 determine minimum current carrying capacity of live conductors for given **installation conditions.**

**Range**

**Installation conditions**: Ib In Iz It, Ca, Cc, Cf, Cg, Ci, voltage drop.

**Cable selection**

The size of a cable to be used for an installation depends upon:

* the current rating of a cable under defined installation conditions
* the maximum permitted drop in voltage, as defined by BS7671 Section 525 with specific values given in BS 7671 Appendix 4, section 6.4
* satisfying earth fault loop impedance requirements specified in BS7671 Regulation Tables 41.2, 41.3 and 41.4.

The factors which influence the current rating are the:

* design current, Ib – the cable must carry the full load current
* type of cable – PVC, MIMS, copper conductors or aluminium conductors
* installed conditions – eg clipped to the surface or installed with other cables in trunking
* surrounding temperature – cable resistance increases as temperature increases and insulation may melt if the temperature is too high
* type and size of protection – for how long will the cable have to carry fault current?

**Current carrying capacity**

In order to comply with BS 7671, the following relationship must be complied with:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
| where: | Ib | = | design current of circuit |
|  | In | = | rated current or current setting of protective device |
|  | Iz | = | current carrying capacity of a cable for continuous service under the particular installation conditions concerned |
| and |  | | |
| where: | It | = | tabulated current carrying capacity of a cable. |

Based on these relationships, the following steps should be taken when determining the cable to be used for a particular situation with respect to current carrying capacity, which must comply with BS 7671 Regulation 523.1.

* Determine the design current (Ib) of the circuit. This should be the value after applying any applicable factors for diversity.
* Select the type and current rating of the protective device, which must be equal to or larger than the design current (In).
* Determine the various correction factors applicable and apply them to the protective rating.
* Determine the installation method to be used.
* Select the cable from the current carrying capacity tables in Appendix 4 of BS 7671.

A number of correction factors are available to take into account various installation conditions. These are as follows:

|  |  |
| --- | --- |
| Ca | ambient or surrounding temperature correction factor which is given in Tables 4B1 and 4B2 of BS7671 Appendix 4. |
| Cc | for circuits buried directly in the ground or in a duct in the ground Cc = 0.9 (Appendix 4 section 5.1 – page 333). For cables installed above ground Cc = 1. |
| Cd | for depth of burial correction factor, which is given in Table 4B4 of BS7671 Appendix 4. |
| Cf | where the protective device is a semi-enclosed fuse to BS3036, Cf = 0.725, otherwise Cf = 1 (Appendix 4 section 5.1). |
| Cg | grouping correction factor given in Tables 4C1 to 4C6 of BS7671 Appendix 4. |
| Ci | correction factor to be used when cables are enclosed in thermal insulation. BS7671 Regulation 523.9 gives three possible correction values:   * where a cable is installed in a thermally insulated wall or above a thermally insulated ceiling, the cable being in contact with a thermally conductive surface on one side, current carrying capacities are tabulated in Appendix 4 * where the cable is totally surrounded over a length greater than 0.5m, a factor of 0.5 must be applied * where the cable is totally surrounded over a short length less than 0.5m, the appropriate factor given in Table 52.2 of BS7671 should be applied. |
| Cs | for thermal resistivity of soil correction factor, which is given in Table 4B3 of BS7671 Appendix 4. |

These factors are to be divided into the rated current or current setting of protective device (In).

If the factors occur at the same time, eg a certain number of cables grouped together in a certain ambient temperature, then all the relevant factors are divided into the value of In. However, if the factors occur at different points in the cable run, eg a certain number of cables grouped together that separate before passing through an area of elevated ambient temperature, then only the ‘worst case’ factor needs to be applied.

Dividing the value of In by all the appropriate factors will give use the current carrying capacity of the cable for continuous service under the particular installation conditions concerned (Iz).

Then the appropriate cable type table must be selected from those in Appendix 4 of BS 7671, as well as the appropriate installation reference method column in that table. A cable with a tabulated current carrying capacity (It) greater than Iz is selected.

**Example 1**

A 6.5kW, 230V shower unit is to be wired in a domestic bathroom some 18m away from the mains consumer unit. A general purpose thermoplastic PVC insulated and sheathed flat twin with cpc cable will be clipped to the side of the 100mm ceiling joists over much of its length with one other similar cable in a roof space which, it is anticipated, will reach 35°C in the summer and where thermal insulation is installed up to the top of the joists. Assuming a TN‑S supply, calculate the minimum cable size to carry the current if the circuit is to be protected by:

1. a semi-enclosed fuse to BS3036
2. a Type B CB to BS EN 60898.

**Solution:**

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| --- | --- | --- | --- |
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|  |  |  |  |
|  |  |  |  |
| a) |  |  |  |

The correction factors to be included in this calculation are:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Ca** | ambient temperature; the correction factor for 35°C is 0.94 from Table 4B1 of Appendix 4 | | |
|  | **Cc** | cable is installed above ground so Cc = 1 | | |
|  | **Cd** | as the cable is installed above ground, this factor does not apply | | |
|  | **Cf** | the protection is by a semi-enclosed fuse and, therefore, a factor of 0.725 must be applied | | |
|  | **Cg** | the cable is grouped with one similar cable so we have a factor of 0.8 from Table 4C1 of Appendix 4 | | |
|  | **Ci** | thermal insulation is in contact with one side of the cable and therefore current carrying capacities are tabulated in Appendix 4 | | |
|  | **Cs** | as the cable is installed above ground, this factor does not apply. | | |
|  |  | |  |  |
|  |  | |  |  |
|  |  | |  |  |

The installation method is from Table 4A2 Reference Method 100.

From Column 2 of Table 4D5 a **16mm2** cable, having a rating (It) of 57 amperes, is required to carry this current.

We must now check that this cable complies with volt drop requirements. BS 7671 Regulation 525.202 refers to Appendix 4 section 6.4, stating that the drop in voltage between the origin of an installation and any load point must not exceed 3% of the nominal supply voltage for lighting circuits and 5% of the nominal supply voltage for other circuits for low voltage installations supplied directly from a public low voltage distribution system.

The voltage drop for a particular cable may be found from:

Now test for volt drop. The maximum permissible volt drop is 5% of the nominal supply voltage:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
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|  |  |  |  |

From Table 4D5 Column 8 the volt drop per ampere metre for a 16mm2 cable is 2.8mV. Therefore, the volt drop for this cable length and load is equal to:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |

Since this is less than the maximum permissible value of 11.5 volts, a 16mm2 cable satisfies the current carrying capacity and voltage drop requirements, and is therefore the chosen cable when semi-enclosed fuse protection is used.

|  |  |  |  |
| --- | --- | --- | --- |
| b) |  |  |  |

The correction factors to be included in this calculation are:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Ca** | ambient temperature; the correction factor for 35°C is 0.94 from Table 4B1 of Appendix 4 | | |
|  | **Cc** | cable is installed above ground so Cc = 1 | | |
|  | **Cd** | as the cable is installed above ground, this factor does not apply | | |
|  | **Cf** | since protection is by a CB, the factor is 1 | | |
|  | **Cg** | the cable is grouped with one similar cable so we have a factor of 0.8 from Table 4C1 of Appendix 4 | | |
|  | **Ci** | thermal insulation is in contact with one side of the cable and therefore current carrying capacities are tabulated in Appendix 4 | | |
|  | **Cs** | as the cable is installed above ground, this factor does not apply. | | |
|  |  | |  |  |
|  |  | |  |  |
|  |  | |  |  |

The installation method is from Table 4A2 Reference Method 100.

From Column 2 of Table 4D5 a **10mm2** cable, having a rating (It) of 45 amperes, is required to carry this current.

Again, we test for volt drop. The maximum permissible volt drop is 5% of the nominal supply voltage, which we calculated earlier is 11.5 volts.

From Table 4D5 Column 8 the volt drop per ampere metre for a 10mm2 cable is 4.4mV. Therefore, the volt drop for this cable length and load is equal to:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |

Since this is less than the maximum permissible value of 11.5 volts, a 10mm2 cable satisfies the current carrying capacity and voltage drop requirements, and is therefore the chosen cable when circuit breaker type B protection is used.

**NB**: A further step is necessary in the cable selection process. This is to check that the chosen cable complies with the earth loop impedance requirements.

This will be covered later in your studies.

**STEP 1. Find the Design Current (Ib) = \_\_\_\_\_\_KW = \_\_\_\_\_\_\_\_\_\_watts**

**I = P**

**V**

**(Ib) = \_\_\_\_\_\_\_\_\_\_ amps**

**STEP 2. The Protective Device Rating (In) should be equal to or greater than (Ib), so**

**(In) = \_\_\_\_\_\_\_\_amps**

**STEP 3. Apply any correction factors. If no factors need to be applied then (Iz) = (It).**

**Cg = \_\_\_\_\_\_\_\_ (Iz) = \_\_\_\_\_\_(In)\_\_\_\_\_\_\_**

**Cf x Cg x Ci x Ca**

**Ci = \_\_\_\_\_\_\_\_**

**Ca = \_\_\_\_\_\_\_\_**

**Cf (BS 3036 factor) = 0.725 (Iz) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**STEP 4. Select cable size from BS 7671 App 4. (Iz/t) > (In) > (Ib).**

**(Iz/t) = \_\_\_\_\_\_\_\_amps**

**From table \_\_\_\_\_\_\_\_\_\_ Reference Method \_\_\_\_\_\_\_\_\_\_ Cable size = \_\_\_\_\_\_\_mm**

**STEP 5. Volt Drop.**

**Calculate circuit voltage drop, the maximum permitted for a lighting circuit,**

**Is 3%. For all other circuits the maximum permitted is 5%**

**Actual volt drop VD = Length of circuit x design current x mV/A/m**

**1000**

**= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**1000**

**= \_\_\_\_\_\_\_\_\_\_VD**