**The Open University of Sri Lanka**
**Diploma in Technology**
**ECX4234-Electrical Installation**
**Final Examination 2007/2008**

**Date: Friday 15th May 2008** **Time:9.30-12.30 hrs.**

**This paper contains 12 pages with Eight (8) questions. Answer Five (5) questions. All questions carry equal marks. Graph papers will be available on your request.**

**(1)** A 230 V single-phase circuit is run in two-core (with circuit protective conductor) 70 $^0$C pvc-insulated sheathed cable having copper conductors of 2.5 $mm^2$ cross sectional area for the live conductors and 1.5 $mm^2$ for the protective conductor.

If the length of the conductor path is 55 m and the earth fault loop impedance external to the installation is, i.e. $Z_E = 0.8\ \Omega$ and if the circuit is protected by a 30 mA RCCB, check whether the circuit is satisfying the adiabatic equation given in the IEE regulation #543-01-03, i.e. $s = \frac{\sqrt{I^2 t}}{k}$

*(Assume that the parameter k to be 115 and RCCB to operate within 0.04 s at a residual current of 5 $I_{\Delta n}$ Amperes.)*

Also calculate the maximum time the conductor can withstand as per the adiabatic equation, if one wished to introduce an internal time delay for the RCCB.

*(The required table for the above calculation is attached as table 8D, IEE wiring regulation 15th edition, Page 3 of 14.)*

**(2)** State the factors on which the capacity of a conduit to carry cables depends?
It is intended to run five single-core PVC insulated 2.5 $mm^2$ cables and four similar cables but of 4 $mm^2$ cross section in a conduit. The estimated length of conduit run is 10 meters and the run include 2 bends. Determine the minimum size of conduit that can be used for this purpose? Also, estimate the minimum radius of the conduit bends to be used in the above installation.

*(You may refer to the appropriate tables given in the appendix 12, pages (180-182) of IEE wiring regulation 15th edition attached to this question paper. Page 4,5,6 of 14. )*

**(3)** Why is the IEE regulation specify that we must use one-quarter (1/4) of the total impedance of the ring circuit measured between disconnected ends when calculating the earth fault loop impedance?
A single-phase ring circuit is run in 2.5 $mm^2$ 70 $^0$C PVC-insulated and sheathed flat cable with a protective conductor of cross sectional area 1.5 $mm^2$. If the circuit length is 65 m long and $Z_E$ = 0.35 Ohm ($Z_E$ = earth fault loop impedance external to the installation), what is the earth fault loop impedance of the circuit? Also, check whether the circuit is in compliance with the adiabatic equation? Assume K=115 & t = 0.04 s.

*(The required table for the above calculation is attached as table 8D, IEE wiring regulation 15th edition, Page 3 of 13.)*

(4) The owner of a premise to be provided with electrical wiring has the following requirements for his premises:

- 12 Nos. of fluorescent lamps
- 15 Nos. of incandescent lamps
- 2 Nos. of air-conditioners 2.5 kW at 0.85 p.f. lagging on full load
- 2 Nos. of refrigerators consuming 0.75 kW at 0.9 p.f. lagging on full load
- 2 Nos. of electric heaters rated at 2.0 kW
- One, electric. cooker with 3 elements each rated at 1.2 kW & an oven rated at 2.0 kW.
- One, ½ h.p water pump with an efficiency 0.9 & 0.8 p.f. lagging. (1 h.p. = 746 W)
- One colour television rated at 120 W
- 3 Nos. of 30 A ring circuit to cater for unspecified number of appliances

Design a suitable electrical distribution system to cater for the requirements of the owner of the premises indicating its single line configuration. The supply to the premises would be 3- phase, 400 V, 50 Hz. What is your recommendation for the rating of the current requirement for the premises? Justify your recommendations.

(5) A single-phase circuit has a design current $I_b$ = 17 A and is to wired in flat two-core 70 $^0$C pvc-insulated and sheathed cable to BS6004 having copper conductors, grouped with four other similar cables, all clip direct.
If $t_a$ = 45 $^0$C and the circuit is to be protected against both overload and short circuit by a semi-enclosed fuse to BS3036, what should be the nominal current rating of that fuse and the minimum cross-sectional area of cable conductor?

*(Please refer to the attached fig. 3.2A, Page 7 of 13 & 3.2B, page 8 of 13 for BS 3036 semi enclosed fuse characteristics and Table 4B1, 4C2 & Table 4D2A for various other parameters obtained from IEE wiring regulation 16$^{th}$ edition.)*

(6) What are the tests you would normally carry out for a domestic electrical installation before requesting the supply authority to provide power supply to it.? Describe all these tests (you may use sketches)?

(7) A single-phase circuit having a design current of 26 A is protected by a 32 A BS88 fuse and is wired in single-core 70 $^0$C pvc-insulated non-sheathed cables having copper conductors. It is installed with six other similar circuits in conduit on a wall in a location where the ambient temperature is 45 $^0$C. What is the minimum conductor cross-sectional area that can be used for the circuit?
*(Please refer to the attached fig. 3.3A, Page 13 of 14 & 3.3B, page 14 of 14 for BS88 fuse characteristics and Table 4B1, 4C1 & Table 4D1A for various other parameters obtained from IEE wiring regulation 16$^{th}$ edition..)*

(8) Define any **FIVE** of the followings

(a) Earth resistivity of soil
(b) Earth loop impedance
(c) Discrimination in protective devices
(d) Maximum Demand
(e) Electric Shock
(f) Diversity as applied to current demand of an installation

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## TABLE 8D

Values of $(R_1 + R_2)$ per metre for p.v.c.-insulated copper conductors

| Cross-sectional area, mm² | | $(R_1 + R_2)$ ohms/metre |
|---|---|---|
| Phase conductor | Protective conductor | |
| 1 | 1 | 0.055 |
| 1.5 | 1 | 0.046 |
| | 1.5 | 0.037 |
| 2.5 | 1 | 0.039 |
| | 1.5 | 0.030 |
| | 2.5 | 0.022 |
| 4 | 1.5 | 0.026 |
| | 2.5 | 0.018 |
| | 4 | 0.014 |
| 6 | 2.5 | 0.016 |
| | 4 | 0.0116 |
| | 6 | 0.0092 |
| 10 | 4 | 0.0098 |
| | 6 | 0.0074 |
| | 10 | 0.0055 |
| 16 | 6 | 0.0064 |
| | 10 | 0.0045 |
| | 16 | 0.0035 |

# APPENDIX 12

## CABLE CAPACITIES OF CONDUIT AND TRUNKING

### Introduction

This appendix describes a method which can be used to determine the size of conduit or trunking necessary to accommodate cables of the same size, or differing sizes, and provides a means of compliance with Regulation 529–7.

The method employs a 'unit system', each cable size being allocated a factor. The sum of all factors for the cables intended to be run in the same enclosure is compared against the factors given for conduit or trunking, as appropriate, in order to determine the size of the conduit or trunking necessary to accommodate those cables.

It has been found necessary, for conduit, to distinguish between –

1. straight runs not exceeding 3 metres in length, and
2. straight runs exceeding 3 metres, or runs of any length incorporating bends or sets.

The term 'bend' signifies a British Standard 90° bend, and one double set is equivalent to one bend.

For the case 1, each conduit size is represented by only one factor. For the case 2, each conduit size has a variable factor which is dependent on the length of run and the number of bends or sets. For a particular size of cable the factor allocated to it for case 1 is not the same as for case 2.

For trunking each size of cable has been allocated a factor, as has been each size of trunking.

Because of certain aspects, such as the assessment of reasonable care of pulling-in, acceptable utilisation of the space available and the dimensional tolerances of cables, conduit and trunking, any method of standardizing the cable capacities of such enclosures can only give guidance on the number of cables which can be accommodated. Thus the sizes of conduit or trunking determined by the method given in this appendix are those which can be reasonably expected to accommodate the desired number of cables in a particular run using an acceptable pulling force and with the minimum probability of damage to cable insulation.

Only mechanical considerations have been taken into account in determining the factors given in the following tables. As the number of circuits in a conduit or trunking increases, the current-carrying capacities of the cables must be reduced according to the appropriate grouping factors in Appendix 9. It may therefore be more attractive economically to divide the circuits concerned between two or more enclosures.

This appendix deals with the following four cases:

– Single-core p.v.c.-insulated cables in straight runs of conduit not exceeding 3m in length.

– Single-core p.v.c.-insulated cables in straight runs of conduit exceeding 3m in length, or in runs of any length incorporating bends or sets.

– Single-core p.v.c.-insulated cables in trunking.

– Other sizes and types of cable in trunking.

For other cables and/or conduits not covered by the tables, advice on the number of cables which can be accommodated should be obtained from the manufacturers.

### Single-core p.v.c.-insulated cables in straight runs of conduit not exceeding 3m in length.

For each cable it is intended to use, obtain the appropriate factor from Table 12A.

Add all the cable factors so obtained and compare with the conduit factors given in Table 12B.

The conduit size which will satisfactorily accommodate the cables is that size having a factor equal to or exceeding the sum of the cable factors.

TABLE 12A

Cable factors for short straight runs

| Type of conductor | Conductor cross-sectional area mm² | Factor |
|---|---|---|
| Solid | 1 | 22 |
| | 1.5 | 27 |
| | 2.5 | 39 |
| Stranded | 1.5 | 31 |
| | 2.5 | 43 |
| | 4 | 58 |
| | 6 | 88 |
| | 10 | 146 |

TABLE 12B

Conduit factors for short straight runs

| Conduit dia mm | Factor |
|---|---|
| 16 | 290 |
| 20 | 460 |
| 25 | 800 |
| 32 | 1400 |

**Single-core p.v.c.-insulated cables in straight runs of conduit exceeding 3m in length or in runs of any length incorporating bends or sets.**

For each cable it is intended to use, obtain the appropriate factor from Table 12C.

Add all the cable factors so obtained and compare with the conduit factors given in Table 12D, taking into account the length of run it is intended to use and the number of bends and sets in that run.

The conduit size which will satisfactorily accommodate the cables is that size having a factor equal to or exceeding the sum of the cable factors.

TABLE 12C

Cable factors for long straight runs, or runs incorporating bends

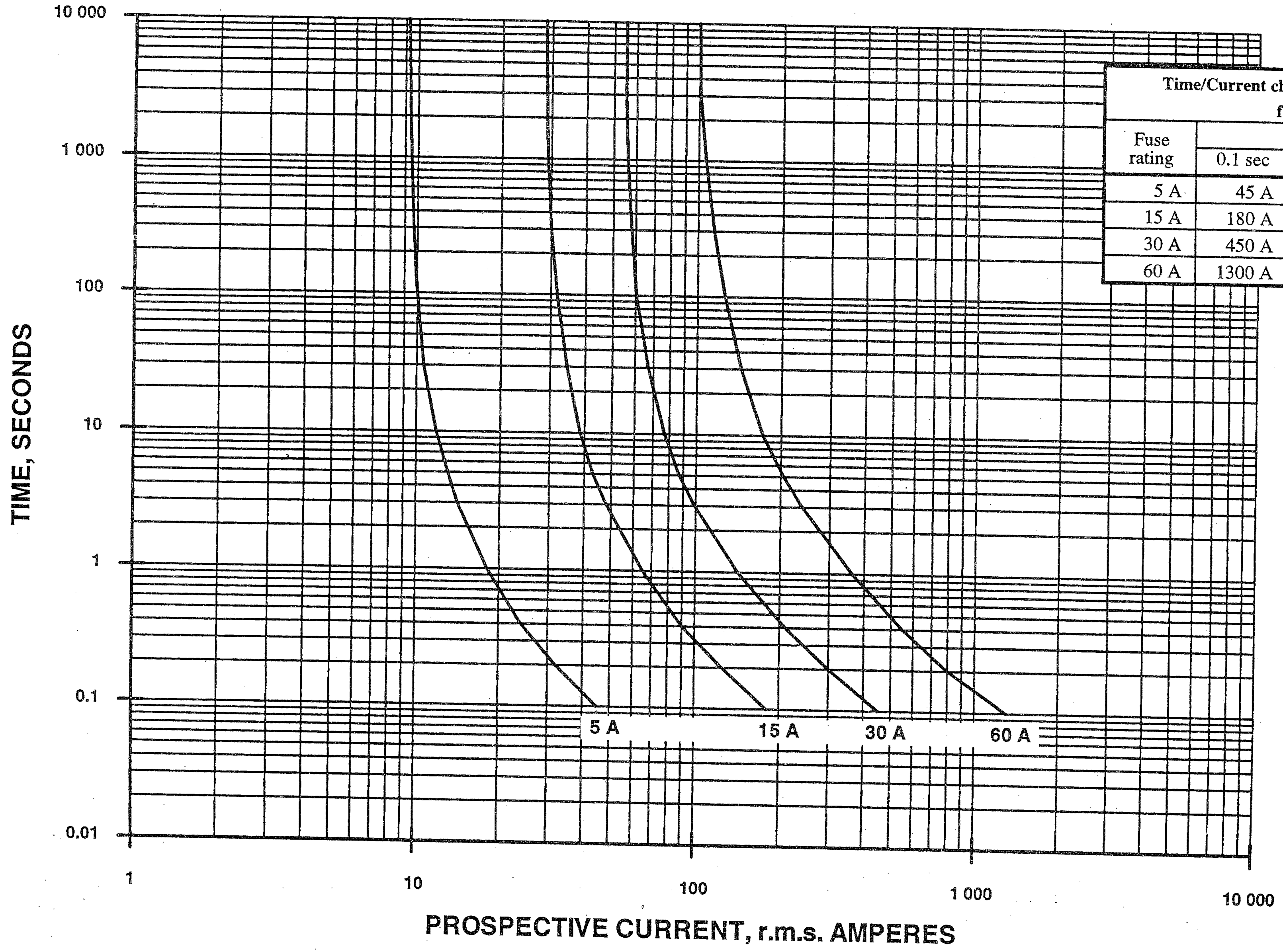
| Type of conductor | Conductor cross-sectional area mm² | Factor |
|---|---|---|
| Solid or stranded | 1 | 16 |
| | 1.5 | 22 |
| | 2.5 | 30 |
| | 4 | 43 |
| | 6 | 58 |
| | 10 | 105 |

## TABLE 12D

### Conduit factors for runs incorporating bends

| Length of run m | Conduit diameter, mm | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 20 | 25 | 32 | 16 | 20 | 25 | 32 | 16 | 20 | 25 | 32 | 16 | 20 | 25 | 32 | 16 | 20 | 25 | 32 |
| | Straight | | | | One bend | | | | Two bends | | | | Three bends | | | | Four bends | | | |
| 1 | Covered by Tables 12A and 12B | | | | 188 | 303 | 543 | 947 | 177 | 286 | 514 | 900 | 158 | 256 | 463 | 818 | 130 | 213 | 388 | 692 |
| 1.5 | | | | | 182 | 294 | 528 | 923 | 167 | 270 | 487 | 857 | 143 | 233 | 422 | 750 | 111 | 182 | 333 | 600 |
| 2 | | | | | 177 | 286 | 514 | 900 | 158 | 256 | 463 | 818 | 130 | 213 | 388 | 692 | 97 | 159 | 292 | 529 |
| 2.5 | | | | | 171 | 278 | 500 | 878 | 150 | 244 | 442 | 783 | 120 | 196 | 358 | 643 | 86 | 141 | 260 | 474 |
| 3 | | | | | 167 | 270 | 487 | 857 | 143 | 233 | 422 | 750 | 111 | 182 | 333 | 600 | | | | |
| 3.5 | 179 | 290 | 521 | 911 | 162 | 263 | 475 | 837 | 136 | 222 | 404 | 720 | 103 | 169 | 311 | 563 | | | | |
| 4 | 177 | 286 | 514 | 900 | 158 | 256 | 463 | 818 | 130 | 213 | 388 | 692 | 97 | 159 | 292 | 529 | | | | |
| 4.5 | 174 | 282 | 507 | 889 | 154 | 250 | 452 | 800 | 125 | 204 | 373 | 667 | 91 | 149 | 275 | 500 | | | | |
| 5 | 171 | 278 | 500 | 878 | 150 | 244 | 442 | 783 | 120 | 196 | 358 | 643 | 86 | 141 | 260 | 474 | | | | |
| 6 | 167 | 270 | 487 | 857 | 143 | 233 | 422 | 750 | 111 | 182 | 333 | 600 | | | | | | | | |
| 7 | 162 | 263 | 475 | 837 | 136 | 222 | 404 | 720 | 103 | 169 | 311 | 563 | | | | | | | | |
| 8 | 158 | 256 | 463 | 818 | 130 | 213 | 388 | 692 | 97 | 159 | 292 | 529 | | | | | | | | |
| 9 | 154 | 250 | 452 | 800 | 125 | 204 | 373 | 667 | 91 | 149 | 275 | 500 | | | | | | | | |
| 10 | 150 | 244 | 442 | 783 | 120 | 196 | 358 | 643 | 86 | 141 | 260 | 474 | | | | | | | | |

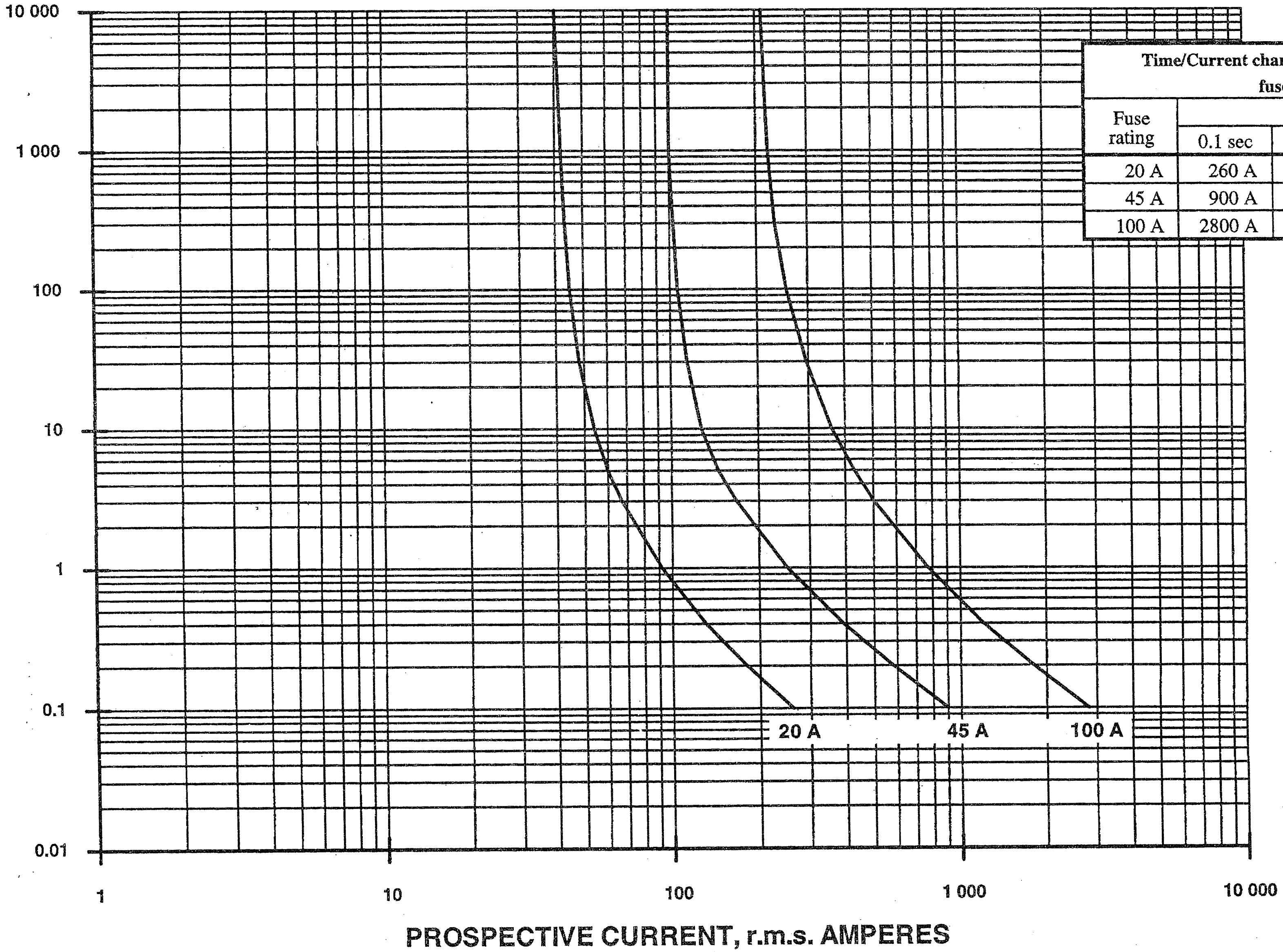
*fig 3.2A* **Semi-enclosed fuses to BS 3036**




**Time/Current characteristics for semi-enclosed fuses to BS 3036**

| Fuse rating | Current for time | | | |
|---|---|---|---|---|
| | 0.1 sec | 0.2 sec | 0.4 sec | 5 secs |
| 5 A | 45 A | 32 A | 24 A | 13 A |
| 15 A | 180 A | 125 A | 90 A | 43 A |
| 30 A | 450 A | 300 A | 210 A | 87 A |
| 60 A | 1300 A | 800 A | 550 A | 205 A |

fig 3.2B **Semi-enclosed fuses to BS 3036**




**Time/Current characteristics for semi-enclosed fuses to BS 3036**

| Fuse rating | Current for time | | | |
|---|---|---|---|---|
| | 0.1 sec | 0.2 sec | 0.4 sec | 5 secs |
| 20 A | 260 A | 180 A | 130 A | 60 A |
| 45 A | 900 A | 580 A | 390 A | 145 A |
| 100 A | 2800 A | 1800 A | 1200 A | 430 A |

## TABLE 4B1

**Correction factors for groups of more than one circuit of single-core cables, or more than one multicore cable (to be applied to the corresponding current-carrying capacity for a single circuit in Tables 4D1 to 4D4, 4E1 to 4E4, 4F1 and 4F2, 4J1, 4K1 to 4K4, 4L1 to 4L4)****

| Reference method of installation (see Table 4A1) | | Correction factor ($C_g$) – Number of circuits or multicore cables | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 |
| Enclosed (Method 3 or 4) or bunched and clipped direct to a non-metallic surface (Method 1) | | 0.80 | 0.70 | 0.65 | 0.60 | 0.57 | 0.54 | 0.52 | 0.50 | 0.48 | 0.45 | 0.43 | 0.41 | 0.39 | 0.38 |
| Single layer clipped to a non-metallic surface (Method 1) | Touching | 0.85 | 0.79 | 0.75 | 0.73 | 0.72 | 0.72 | 0.71 | 0.70 | - | - | - | - | - | - |
| | Spaced* | 0.94 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| Single layer *multicore* on a perforated metal cable tray, vertical or horizontal (Method 11) | Touching | 0.86 | 0.81 | 0.77 | 0.75 | 0.74 | 0.73 | 0.73 | 0.72 | 0.71 | 0.70 | - | - | - | - |
| | Spaced*# | 0.91 | 0.89 | 0.88 | 0.87 | 0.87 | - | - | - | - | - | - | - | - | - |
| Single layer *single-core* on a perforated metal cable tray, touching (Method 11) | Horizontal | 0.90 | 0.85 | - | - | - | - | - | - | - | - | - | - | - | - |
| | Vertical | 0.85 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Single layer multicore touching on ladder supports (Method 13) | | 0.86 | 0.82 | 0.80 | 0.79 | 0.78 | 0.78 | 0.78 | 0.77 | - | - | - | - | - | - |

* Spaced by a clearance between adjacent surfaces of at least one cable diameter ($D_e$). Where the horizontal clearance between adjacent cables exceeds 2 $D_e$ no correction factor need be applied.

** When cables having differing conductor operating temperatures are grouped together, the current rating shall be based upon the lowest operating temperature of any cable in the group.

\- Correction factor not tabulated.

\# Not applicable to mineral insulated cables, see Table 4B2.

## TABLE 4B2

**Correction factors for mineral insulated cables installed on perforated tray, (to be applied to the corresponding current-carrying capacity for single circuits for Reference Method 11 in Table 4J1A)**

| Tray orientation | Arrangement of cables | Number of trays | Number of multicore cables or circuits | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 6 | 9 |
| Horizontal | Multiconductor cables touching | 1 | 1.0 | 0.90 | 0.80 | 0.80 | 0.75 | 0.75 |
| Horizontal | Multiconductor cables spaced ‡ | 1 | 1.0 | 1.0 | 1.0 | 0.95 | 0.90 | - |
| Vertical | Multiconductor cables touching | 1 | 1.0 | 0.90 | 0.80 | 0.75 | 0.75 | 0.70 |
| Vertical | Multiconductor cables spaced ‡ | 1 | 1.0 | 0.90 | 0.90 | 0.90 | 0.85 | - |
| Horizontal | Single conductor cables trefoil separated ‡‡ | 1 | 1.0 | 1.0 | 0.95 | | | |
| Vertical | Single conductor cables trefoil separated ‡‡ | 1 | 1.0 | 0.90 | 0.90 | | | |

‡ Spaced by a clearance between adjacent surfaces of at least one cable diameter ($D_e$).

‡‡ Separated by a clearance between adjacent surfaces of at least two cable diameters (2 $D_e$).

\- Correction factor not tabulated.

### NOTES to Tables 4B1 and 4B2

1. The factors in the table are applicable to groups of cables all of one size. The value of current derived from application of the appropriate factors is the maximum current to be carried by any of the cables in the group.
2. If, due to known operating conditions, a cable is expected to carry not more than 30 % of its *grouped* rating, it may be ignored for the purpose of obtaining the rating factor for the rest of the group.
   For example, a group of N loaded cables would normally require a group reduction factor of $C_g$ applied to the tabulated $I_t$. However, if M cables in the group carry loads which are not greater than 0.3 $C_g I_t$ amperes the other cables can be sized by using the group rating factor corresponding to (N-M) cables.
3. When cables having differing conductor operating temperatures are grouped together, the current rating shall be based on the lowest operating temperature of any cable in the group.
4. Where the horizontal clearance between adjacent cables exceeds 2 $D_e$, no correction factor need be applied.

## TABLE 4C1
### Correction factors for ambient temperature where protection is against short-circuit

NOTE: This table applies where the associated overcurrent protective device is intended to provide short-circuit protection only. Except where the device is a semi-enclosed fuse to BS 3036 the table also applies where the device is intended to provide overload protection.

| Type of insulation | Operating temperature | Ambient temperature (°C) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 |
| Thermosetting (rubber) (flexible cables only) | 60 °C | 1.04 | 1.0 | 0.91 | 0.82 | 0.71 | 0.58 | 0.41 | - | - | - | - | - | - | - | - |
| Thermoplastic (General purpose pvc) | 70 °C | 1.03 | 1.0 | 0.94 | 0.87 | 0.79 | 0.71 | 0.61 | 0.50 | 0.35 | - | - | - | - | - | - |
| Paper | 80 °C | 1.02 | 1.0 | 0.95 | 0.89 | 0.84 | 0.77 | 0.71 | 0.63 | 0.55 | 0.45 | 0.32 | - | - | - | - |
| Thermosetting (rubber) | 85 °C | 1.02 | 1.0 | 0.95 | 0.90 | 0.85 | 0.80 | 0.74 | 0.67 | 0.60 | 0.52 | 0.43 | 0.30 | - | - | - |
| Thermoplastic ( high temperature pvc)* | 90 °C | 1.03 | 1.0 | 0.97 | 0.94 | 0.91 | 0.87 | 0.84 | 0.80 | 0.76 | 0.71 | 0.61 | 0.50 | 0.35 | - | - |
| Thermosetting | 90 °C | 1.02 | 1.0 | 0.96 | 0.91 | 0.87 | 0.82 | 0.76 | 0.71 | 0.65 | 0.58 | 0.50 | 0.41 | 0.29 | - | - |
| Mineral | 70 °C sheath | 1.03 | 1.0 | 0.93 | 0.85 | 0.77 | 0.67 | 0.57 | 0.45 | 0.31 | - | - | - | - | - | - |
| | 105 °C sheath | 1.02 | 1.0 | 0.96 | 0.92 | 0.88 | 0.84 | 0.80 | 0.75 | 0.70 | 0.65 | 0.60 | 0.54 | 0.47 | 0.40 | 0.32 |

NOTES:
1. Correction factors for flexible cords and for 85 °C and 180 °C thermosetting (rubber) insulated flexible cables are given in the relevant table of current-carrying capacity.
2. This table also applies when determining the current-carrying capacity of a cable.
3. * These factors are applicable only to ratings in columns 2 to 5 of Table 4D1A.

## TABLE 4C2
### Correction factors for ambient temperature where the overload protective device is a semi-enclosed fuse to BS 3036.

| Type of insulation | Operating temperature | Ambient temperature (°C) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 |
| Thermosetting (rubber) (flexible cables only) | 60 °C | 1.04 | 1.0 | 0.96 | 0.91 | 0.87 | 0.79 | 0.56 | - | - | - | - | - | - | - | - |
| Thermoplastic (General purpose pvc) | 70 °C | 1.03 | 1.0 | 0.97 | 0.94 | 0.91 | 0.87 | 0.84 | 0.69 | 0.48 | - | - | - | - | - | - |
| Paper | 80 °C | 1.02 | 1.0 | 0.97 | 0.95 | 0.92 | 0.90 | 0.87 | 0.84 | 0.76 | 0.62 | 0.43 | - | - | - | - |
| Thermosetting (rubber) | 85 °C | 1.02 | 1.0 | 0.97 | 0.95 | 0.93 | 0.91 | 0.88 | 0.86 | 0.83 | 0.71 | 0.58 | 0.41 | - | - | - |
| Thermoplastic ( high temperature pvc)* | 90 °C | 1.03 | 1.0 | 0.97 | 0.94 | 0.91 | 0.87 | 0.84 | 0.80 | 0.76 | 0.72 | 0.68 | 0.63 | 0.49 | - | - |
| Thermosetting | 90 °C | 1.02 | 1.0 | 0.98 | 0.95 | 0.93 | 0.91 | 0.89 | 0.87 | 0.85 | 0.79 | 0.69 | 0.56 | 0.39 | - | - |
| Mineral: bare and exposed to touch or pvc covered | 70 °C sheath | 1.03 | 1.0 | 0.96 | 0.93 | 0.89 | 0.86 | 0.79 | 0.62 | 0.42 | - | - | - | - | - | - |
| Mineral: bare and not exposed to touch | 105 °C sheath | 1.02 | 1.0 | 0.98 | 0.96 | 0.93 | 0.91 | 0.89 | 0.86 | 0.84 | 0.82 | 0.79 | 0.77 | 0.64 | 0.55 | 0.43 |

NOTES:
1. Correction factors for flexible cords and for 85 °C and 180 °C thermosetting (rubber) insulated flexible cables are given in the relevant table of current-carrying capacity.
2. * These factors are applicable only to ratings in columns 2 to 5 of Table 4D1A.

## TABLE 4D1A

**Single-core 70 °C thermoplastic (pvc) insulated cables, non-armoured, with or without sheath**
**(COPPER CONDUCTORS)**

CURRENT-CARRYING CAPACITY (amperes):

Ambient temperature: 30 °C
Conductor operating temperature: 70 °C

| Conductor cross-sectional area | Reference Method 4 (enclosed in conduit in thermally insulating wall etc.) | | Reference Method 3 (enclosed in conduit on a wall or in trunking etc.) | | Reference Method 1 (clipped direct) | | Reference Method 11 (on a perforated cable tray horizontal or vertical) | | Reference Method 12 (free air) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Horizontal flat spaced | Vertical flat spaced | Trefoil |
| | 2 cables, single-phase a.c. or d.c. | 3 or 4 cables, three-phase a.c. | 2 cables, single-phase a.c. or d.c. | 3 or 4 cables, three-phase a.c. | 2 cables, single-phase a.c. or d.c. flat and touching | 3 or 4 cables, three-phase a.c. flat and touching or trefoil | 2 cables, single-phase a.c. or d.c. flat and touching | 3 or 4 cables, three-phase a.c. flat and touching or trefoil | 2 cables, single-phase a.c. or d.c. or 3 cables three-phase a.c. | 2 cables, single-phase a.c. or d.c. or 3 cables three-phase a.c. | 3 cables trefoil, three phase a.c. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| (mm$^2$) | (A) | (A) | (A) | (A) | (A) | (A) | (A) | (A) | (A) | (A) | (A) |
| 1 | 11 | 10.5 | 13.5 | 12 | 15.5 | 14 | - | - | - | - | - |
| 1.5 | 14.5 | 13.5 | 17.5 | 15.5 | 20 | 18 | - | - | - | - | - |
| 2.5 | 20 | 18 | 24 | 21 | 27 | 25 | - | - | - | - | - |
| 4 | 26 | 24 | 32 | 28 | 37 | 33 | - | - | - | - | - |
| 6 | 34 | 31 | 41 | 36 | 47 | 43 | - | - | - | - | - |
| 10 | 46 | 42 | 57 | 50 | 65 | 59 | - | - | - | - | - |
| 16 | 61 | 56 | 76 | 68 | 87 | 79 | - | - | - | - | - |
| 25 | 80 | 73 | 101 | 89 | 114 | 104 | 126 | 112 | 146 | 130 | 110 |
| 35 | 99 | 89 | 125 | 110 | 141 | 129 | 156 | 141 | 181 | 162 | 137 |
| 50 | 119 | 108 | 151 | 134 | 182 | 167 | 191 | 172 | 219 | 197 | 167 |
| 70 | 151 | 136 | 192 | 171 | 234 | 214 | 246 | 223 | 281 | 254 | 216 |
| 95 | 182 | 164 | 232 | 207 | 284 | 261 | 300 | 273 | 341 | 311 | 264 |
| 120 | 210 | 188 | 269 | 239 | 330 | 303 | 349 | 318 | 396 | 362 | 308 |
| 150 | 240 | 216 | 300 | 262 | 381 | 349 | 404 | 369 | 456 | 419 | 356 |
| 185 | 273 | 245 | 341 | 296 | 436 | 400 | 463 | 424 | 521 | 480 | 409 |
| 240 | 320 | 286 | 400 | 346 | 515 | 472 | 549 | 504 | 615 | 569 | 485 |
| 300 | 367 | 328 | 458 | 394 | 594 | 545 | 635 | 584 | 709 | 659 | 561 |
| 400 | - | - | 546 | 467 | 694 | 634 | 732 | 679 | 852 | 795 | 656 |
| 500 | - | - | 626 | 533 | 792 | 723 | 835 | 778 | 982 | 920 | 749 |
| 630 | - | - | 720 | 611 | 904 | 826 | 953 | 892 | 1138 | 1070 | 855 |
| 800 | - | - | - | - | 1030 | 943 | 1086 | 1020 | 1265 | 1188 | 971 |
| 1000 | - | - | - | - | 1154 | 1058 | 1216 | 1149 | 1420 | 1337 | 1079 |

COPPER CONDUCTORS

## TABLE 4D2A
### Multicore 70 °C thermoplastic (pvc) insulated and thermosetting insulated cables, non-armoured (COPPER CONDUCTORS)

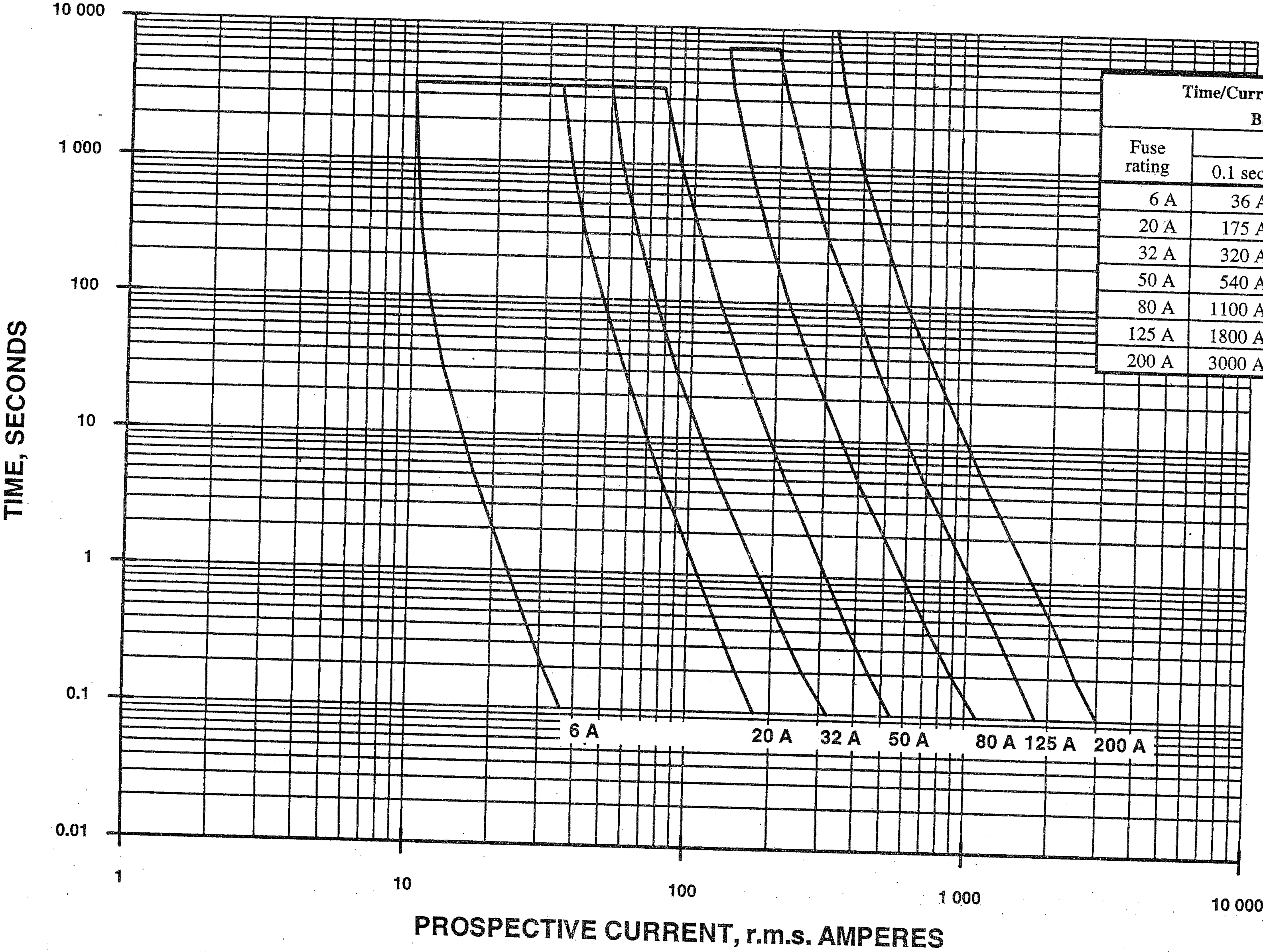
Ambient temperature: 30 °C
Conductor operating temperature: 70 °C

CURRENT-CARRYING CAPACITY (amperes):

| Conductor cross-sectional area | Reference Method 4 (enclosed in an insulated wall, etc.) | | Reference Method 3 (enclosed in conduit on a wall or ceiling, or in trunking) | | Reference Method 1 (clipped direct) | | Reference Method 11 (on a perforated cable tray) or Reference Method 13 (free air) | |
|---|---|---|---|---|---|---|---|---|
| | 1 two-core cable*, single-phase a.c. or d.c. | 1 three-core cable* or 1 four-core cable, three-phase a.c. | 1 two-core cable*, single-phase a.c. or d.c. | 1 three-core cable* or 1 four-core cable, three-phase a.c. | 1 two-core cable*, single-phase a.c. or d.c. | 1 three-core cable* or 1 four-core cable, three-phase a.c. | 1 two-core cable*, single-phase a.c. or d.c. | 1 three-core cable* or 1 four-core cable, three-phase a.c. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| (mm$^2$) | (A) | (A) | (A) | (A) | (A) | (A) | (A) | (A) |
| 1 | 11 | 10 | 13 | 11.5 | 15 | 13.5 | 17 | 14.5 |
| 1.5 | 14 | 13 | 16.5 | 15 | 19.5 | 17.5 | 22 | 18.5 |
| 2.5 | 18.5 | 17.5 | 23 | 20 | 27 | 24 | 30 | 25 |
| 4 | 25 | 23 | 30 | 27 | 36 | 32 | 40 | 34 |
| 6 | 32 | 29 | 38 | 34 | 46 | 41 | 51 | 43 |
| 10 | 43 | 39 | 52 | 46 | 63 | 57 | 70 | 60 |
| 16 | 57 | 52 | 69 | 62 | 85 | 76 | 94 | 80 |
| 25 | 75 | 68 | 90 | 80 | 112 | 96 | 119 | 101 |
| 35 | 92 | 83 | 111 | 99 | 138 | 119 | 148 | 126 |
| 50 | 110 | 99 | 133 | 118 | 168 | 144 | 180 | 153 |
| 70 | 139 | 125 | 168 | 149 | 213 | 184 | 232 | 196 |
| 95 | 167 | 150 | 201 | 179 | 258 | 223 | 282 | 238 |
| 120 | 192 | 172 | 232 | 206 | 299 | 259 | 328 | 276 |
| 150 | 219 | 196 | 258 | 225 | 344 | 299 | 379 | 319 |
| 185 | 248 | 223 | 294 | 255 | 392 | 341 | 434 | 364 |
| 240 | 291 | 261 | 344 | 297 | 461 | 403 | 514 | 430 |
| 300 | 334 | 298 | 394 | 339 | 530 | 464 | 593 | 497 |
| 400 | - | - | 470 | 402 | 634 | 557 | 715 | 597 |

NOTES:
1. **Where the conductor is to be protected by a semi-enclosed fuse to BS 3036, see item 6.2 of the preface to this appendix.**
2. Circular conductors are assumed for sizes up to and including 16 mm$^2$. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.
3. * With or without a protective conductor.

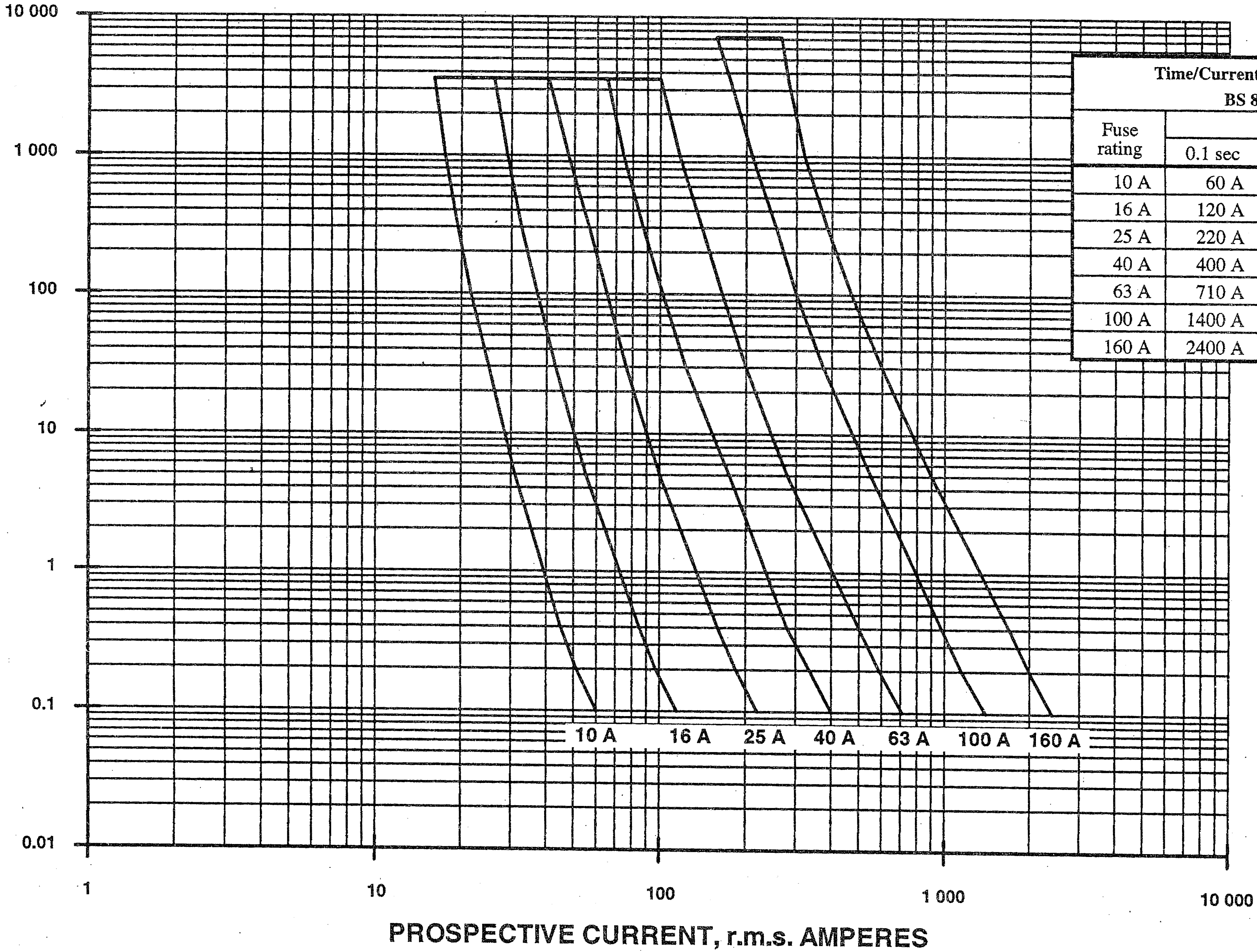
fig 3.3A **Fuses to BS 88-2.1 and BS 88-6**




**Time/Current characteristics for fuses to BS 88-2.1 and BS 88-6**

| Fuse rating | Current for time | | | |
|---|---|---|---|---|
| | 0.1 sec | 0.2 sec | 0.4 sec | 5 secs |
| 6 A | 36 A | 31 A | 27 A | 17 A |
| 20 A | 175 A | 150 A | 130 A | 79 A |
| 32 A | 320 A | 260 A | 220 A | 125 A |
| 50 A | 540 A | 450 A | 380 A | 220 A |
| 80 A | 1100 A | 890 A | 740 A | 400 A |
| 125 A | 1800 A | 1500 A | 1300 A | 690 A |
| 200 A | 3000 A | 2500 A | 2200 A | 1200 A |

fig 3.3B **Fuses to BS 88-2.1 and BS 88-6**




**Time/Current characteristics for fuses to BS 88-2.1 and BS 88-6**

| Fuse rating | Current for time | | | |
|---|---|---|---|---|
| | 0.1 sec | 0.2 sec | 0.4 sec | 5 secs |
| 10 A | 60 A | 51 A | 45 A | 31 A |
| 16 A | 120 A | 95 A | 85 A | 55 A |
| 25 A | 220 A | 180 A | 160 A | 100 A |
| 40 A | 400 A | 340 A | 280 A | 170 A |
| 63 A | 710 A | 590 A | 500 A | 280 A |
| 100 A | 1400 A | 1150 A | 980 A | 550 A |
| 160 A | 2400 A | 2000 A | 1700 A | 900 A |