The Open University of Sri Lanka
Diploma in Technology
ECX4234/ECD2223-Electrical Installation
Final Examination 2006

094

Date: Friday 20th April 2007 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) Give the standard symbols for 15 electrical components used in domestic electrical installation work:

(b) Draw a single line diagram for a fluorescent circuit (consisting of two tubes) to be installed at an industrial type installation, showing the connection of all the associated equipments. What size of a capacitor you would normally use for such circuits? Describe the purpose of this capacitor.

(2) Figure Q2 shows a metal conduit (greater than 3 meters in length) joined to a section of metal trunking in an industrial electrical installation. Determine:

- An appropriate size for the main trunking system
- The size of conduit for load 1
- The number of cables in the conduit for load 2
- The minimum size conduit for load 3

(You may refer to the appropriate tables given in the appendix 12, pages (180-183) of IEE wiring regulation 15th edition attached to this question paper.)

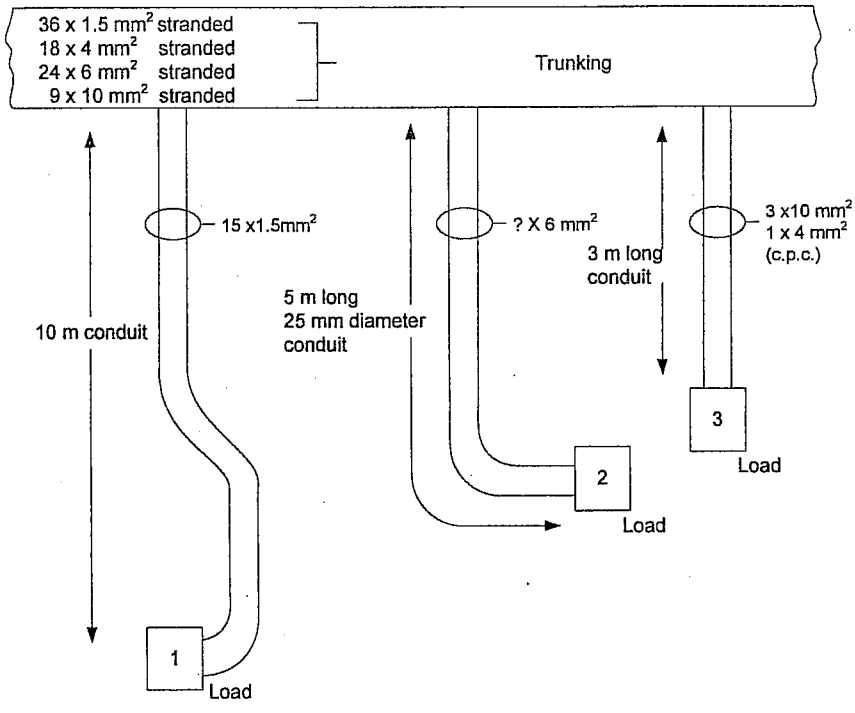


Figure Q2

(3) (a) List the factors affecting the current carrying capacity of a cable?

(b) A PVC insulated and sheathed cable of 2.5 mm^2 feeding a 230 V, 3 kW heater is buried 10 m along its length directly under the plaster. This cable is protected with a 15 A mcb. Due to some reason the cable had to be replaced. The technician who did the job, without burring the new cable of the same size as the old one, passed through a conduit which carried six other multi core cables.

Calculate and show that what he has done is not safe. Assume suitable values for missing parameters. What do you recommend him to do?

(Please refer to the attached table 4A1 for schedule of installations methods of cables and Table 4B1, Table 4D2A & Table 4D2B for various other parameters obtained from IEE wiring regulation 16th edition.)

(4) 12 kW/230 V cooking appliance is to be installed in a domestic dwelling. If the cooker control point is 25 meters away from the main consumer unit and it is wired in PVC/PVC/c.p.c cable, select a suitable size cable for the final circuit?

The following assumptions can be made while doing your calculations:

- The ambient temperature is 30 ^{0}C
- There is a thermal insulation factor to consider affecting one side of the cable (You may use laying method 4 given in Table 4A1 of the IEE regulation 16th edition.)
- The control point incorporates a 13A socket outlet.

(Please refer to the attached Time/current characteristics for type 1 mcb to BS 3871, and Table 4D2A & Table 4D2B for various other parameters obtained from IEE wiring regulation 16th edition.)

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

- 15 Nos of fluorescent lamps
- 18 Nos. of incandescent lamps
- 3 Nos. of air-conditioners 2.5 kW at 0.85 p.f. on full load
- 1 No refrigerator consuming 0.85 kW at 0.8 p.f. on full load
- 1 No electric heater rated at 2.5 kW
- 1 No electric cooker having 3 elements each rated at 1.2 kW and an oven rated at 2.5 kW.
- 1 No water pump rated at 1.2 kW with a power factor of 0.8 lag
- 1 No colour television rated at 180 W
- 1 No 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.

(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) In a radial circuit wired for a socket out let, the protective device must be rated for the conductor current carrying capacity. Why the same can not be applied for a ring circuit? What would be the conductor size as compared to the rating of the protective device rating? Explain?

(8) a) What is the different between **mcb** and a **mccb**?
b) With the aid of suitable diagrams explain the operation of a **mcb**
c) What are the important characteristics of this device?
d) Why **RCCB** will not operate under overload conditions?
e) Why **mcbs** are superior over semi-enclosed ceramic type fuses?
f) Why most of the modern day type electrical appliances such as electric fans, mixers etc. have two pins rather than three (with out an earth wire for frame earth)?

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.

(4)

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								

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

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

Add all the cable factors so obtained and compare with the factors for trunking given in Table 12F.

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

TABLE 12E

Cable factors for trunking

Type of conductor	Conductor cross-sectional area mm²	Factor
Solid	1.5	7.1
	2.5	10.2
Stranded	1.5	8.1
	2.5	11.4
	4	15.2
	6	22.9
	10	36.3

TABLE 12F

Factor for trunking

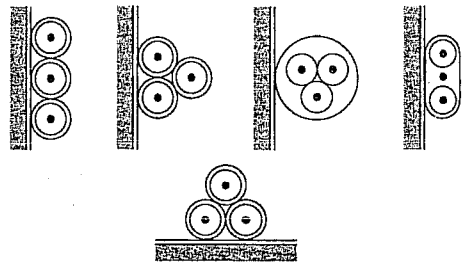
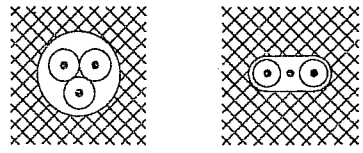
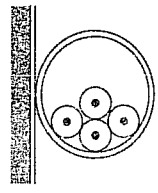
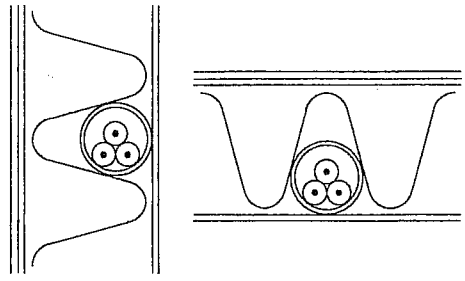
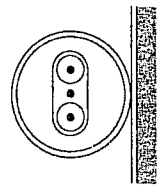
Dimensions of trunking mm x mm	Factor
50 x 37.5	767
50 x 50	1037
75 x 25	738
75 x 37.5	1146
75 x 50	1555
75 x 75	2371
100 x 25	993
100 x 37.5	1542
100 x 50	2091
100 x 75	3189
100 x 100	4252

For other sizes and types of cable or trunking

For sizes and types of cable and sizes of trunking other than those given in Tables 12E and 12F above, the number of cables installed should be such that the resulting space factor (see Part 2: Definitions) does not exceed 45%.

TABLE 4A1

Schedule of Installation Methods of Cables (including Reference Method)

Installation method		Examples	Appropriate Reference Method for determining current-carrying capacity
Number	Description		
1	2	3	4
Open and clipped direct:			
1	**Sheathed cables clipped direct to or lying on a non-metallic surface**		**Method 1**
Cables embedded direct in building materials:			
2	Sheathed cables embedded directly in masonry, brickwork, concrete, plaster or the like (other than thermally insulating materials)		Method 1
In conduit:			
3	**Single-core non-sheathed cables in metallic or non-metallic conduit on a wall or ceiling**		**Method 3**
4	**Single-core non-sheathed cables in metallic or non-metallic conduit in a thermally insulating wall or above a thermally insulating ceiling, the conduit being in contact with a thermally conductive surface on one side †**		**Method 4**
5	Multicore cables having non-metallic sheath, in metallic or non-metallic conduit on a wall or ceiling		Method 3

† The wall is assumed to consist of an outer weatherproof skin, thermal insulation and an inner skin of plasterboard or wood-like material having a coefficient of heat transfer not less than 10 W/m^2K. The conduit is fixed so as to be close to, but not necessarily touching, the inner skin. Heat from the cables is assumed to escape through the inner skin only.

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 4D2A

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

COPPER CONDUCTORS

CURRENT-CARRYING CAPACITY (amperes):

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

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

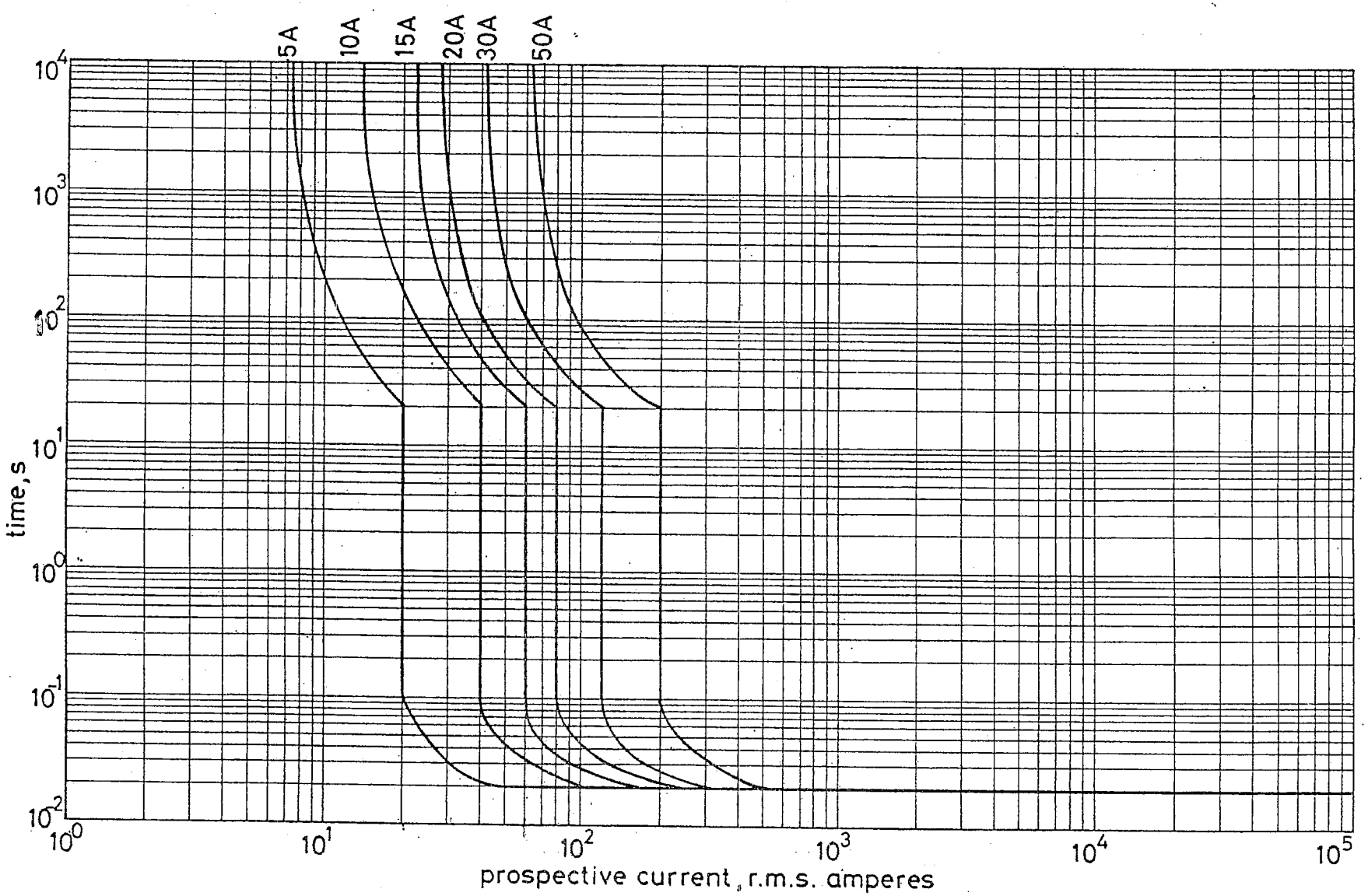
NOTES:

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.

TABLE 4D2B

VOLTAGE DROP (per ampere per metre): Conductor operating temperature: 70 °C

Conductor cross-sectional area	Two-core cable, d.c.	Two-core cable, single-phase a.c.			Three- or four-core cable, three-phase a.c.		
1	2	3			4		
(mm^2)	(mV/A/m)	(mV/A/m)			(mV/A/m)		
1	44	44			38		
1.5	29	29			25		
2.5	18	18			15		
4	11	11			9.5		
6	7.3	7.3			6.4		
10	4.4	4.4			3.8		
16	2.8	2.8			2.4		
		r	x	z	r	x	z
25	1.75	1.75	0.170	1.75	1.50	0.145	1.50
35	1.25	1.25	0.165	1.25	1.10	0.145	1.10
50	0.93	0.93	0.165	0.94	0.80	0.140	0.81
70	0.63	0.63	0.160	0.65	0.55	0.140	0.57
95	0.46	0.47	0.155	0.50	0.41	0.135	0.43
120	0.36	0.38	0.155	0.41	0.33	0.135	0.35
150	0.29	0.30	0.155	0.34	0.26	0.130	0.29
185	0.23	0.25	0.150	0.29	0.21	0.130	0.25
240	0.180	0.190	0.150	0.24	0.165	0.130	0.21
300	0.145	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.100	0.125	0.160



Time/current characteristics for type 1 miniature circuit breakers to BS 3871