The Open University of Sri Lanka
Diploma in Technology
ECX4234-Electrical Installation
Final Examination 2009/2010

Date 06/03/2010 Time:9.30-12.30 hrs.

This paper contains 9 pages with Eight (8) questions. Answer Five (5) questions. All questions carry equal marks.

1. A 230V, single phase circuit is run in 16 mm^2, 2 core, 70 ^0C pvc insulated and sheathed cables (two core resistance 5.84 mΩ/m) with protective copper conductors of size 6 mm^2. If the length of the cable is 35 m, the earth fault loop impedance external to the installation is 0.35 Ω and the circuit is protected against overload by an 80A BS 88: Part 2 fuse, determine whether the circuit complies with the requirements of the adiabatic equation.(assume k=115)

2. A wiring system employing the use of single in steel trunking is to be installed.

   1. Outline the main design and installation considerations with regards to this installation

   2. The trunking at one point will accommodate the following single standard conductors:

Numbers	Area (mm^2)
28	1.5
20	2.5
12	6.0
10	10.0

   Determine the minimum size of trunking to be used.

3. Attached page No. [3] of [3] shows a domestic equipment set-up consisting of:

   a. MCB1 $\Rightarrow$ Supplying 100 W lamp#1, 100 W lamp#2, 100 W lamp#3 5 Amp plug point#4 and 40 W fluorescent lamp#5

   b. MCB2 $\Rightarrow$ Supplying ring circuit with plug points a, b, c, d, e and f (13 Amp sockets)

   c. MCB3 $\Rightarrow$ Supplying plug points p & q (5 Amp sockets)

   d. RCCB, Main switch and a service main

   I Draw the complete wiring diagram starting from the service main on the given Page [3] of [3] and attach it to your answer script. (You may use different colours for phase, neutral and earth wires or different line styles).

   II Determine the rating of MCB2 and the size of the wire use for the ring main circuit.

   III State the main difference between MCB and RCCB

4 Four three-phase identical circuits each having design current of 31 A are to be wired in 70 °C, single core, PVC-insulated non-sheathed cables to BS6004 having copper conductors. All the circuits are installed in trunking in a thermally insulating wall, the trunking is in contact with a thermally conductive surface(you may use reference method 4) on one side.

What is the minimum conductor cross-sectional area that can be used, if all the circuits are protected against both overload and short circuit by 32 A BS 88 'gG' fuses and the ambient temperature = 45° C.

What will be the cross sectional area if the cables are enclosed in a conduit totally surrounded by a thermally insulating material.

5 (a) Explain briefly why the starting current of an induction motor (for direct–on–line starting) is higher than the full load current.

(b) In what range would be the magnitude of the starting current of an induction motor compared to its full load current?.

(c) What are the factors you should take in to account when calculating the connection cable cross sectional area for a frequent stopping and stating motor?

(d) A 5.9 kW, 230V single-phase motor operating at 0.85 pf and 0.97 efficiency is subject to frequent stopping and starting. The cable supplying the motor through a direct-on-line starter. The cable is clipped-direct consisting of two core, non-armored cable and having 85°C rubber insulation and copper conductors.
If the ambient temperature is 45°C what should be the conductor cross-sectional area?
[Assume that the circuit over-current protective device is other than BS3036 semi-enclosed fuse]

6. Define the following terms:

(a) Conductor current – carrying capacity
(b) Earth fault loop impedance
(c) Equipotential bonding
(d) Earth leakage current
(e) Fault current
(f) Short circuit current

7. (a) Give the standard symbols for 15 electrical components used in domestic electrical installation work:

(b) SELV is one of the basic measures used in the IEE wiring regulations. Explain very briefly what SELV is? With SELV, if enclosures are used, it is recommended that they satisfy IP2X. Explain very briefly what this means.

8. Explain briefly why it is usually necessary to use a residual current device to protect against indirect contact in a TT system, but not in a TN system.
Why it is required for the overload protective device to operate within 0.4 S protection against indirect contact, but not specified for residual current device.

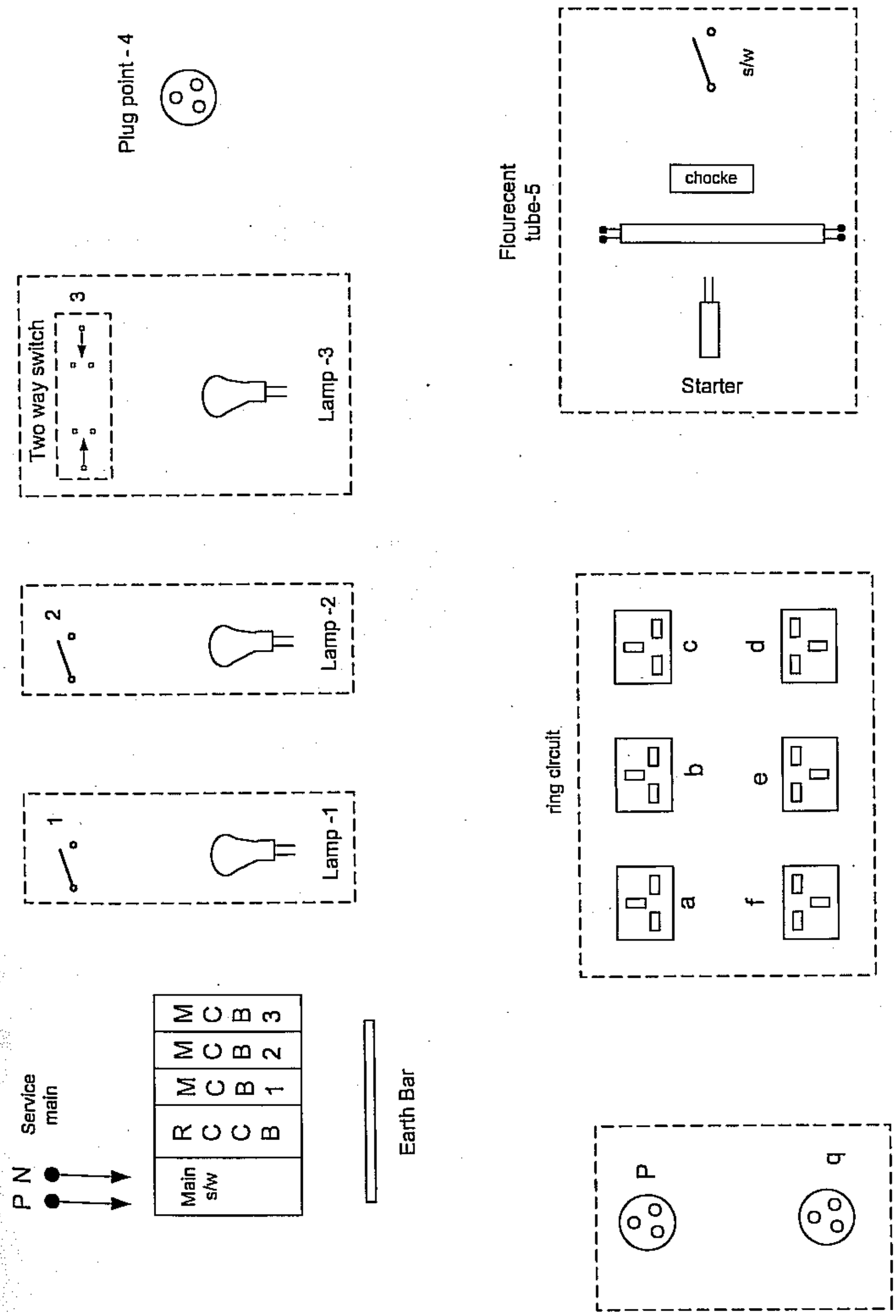
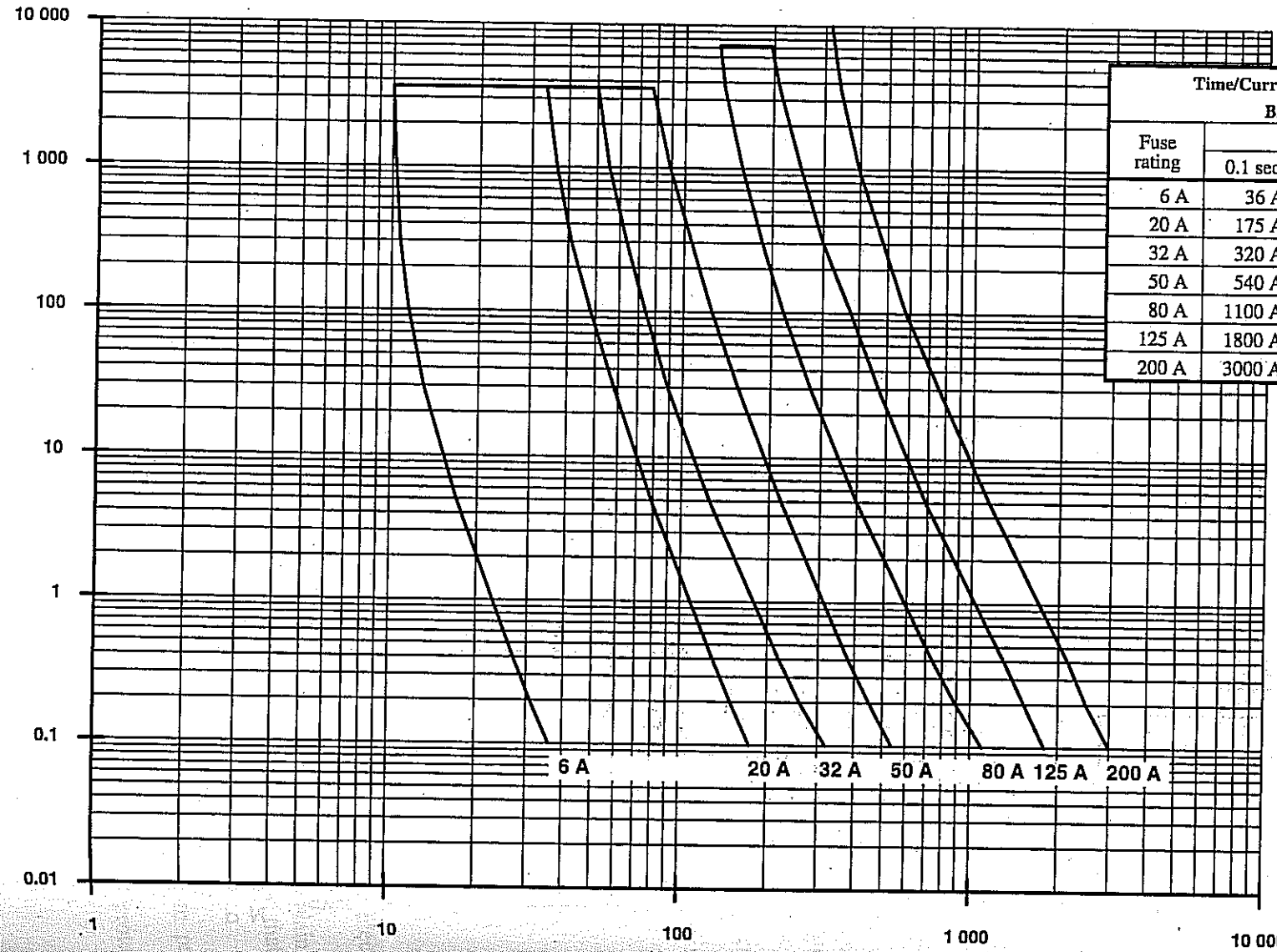

Plug point - 4
Flourecent tube-5
chocke
s/w
Starter
Two way switch
3
Lamp -3
2
Lamp -2
1
Lamp -1
ring circuit
a
b
c
d
e
f
Service main
P N
Main s/w
RCCB
MCB 1
MCB 2
MCB 3
Earth Bar
p
q

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

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 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.

COPPER CONDUCTORS

TABLE 4F2A

Multicore 85 °C thermosetting (rubber) insulated cables with sheath, non-armoured (COPPER CONDUCTORS)

Ambient temperature: 30 °C
Conductor operating temperature: 85 °C

CURRENT-CARRYING CAPACITY (amperes):

Conductor cross-sectional area	Reference Method 3 (enclosed)		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- or four-core cable, three-phase a.c.	1 two-core cable, single-phase a.c. or d.c.	1 three- or four-core cable, three-phase a.c.	1 two-core cable, single-phase a.c. or d.c.	1 three- or four-core cable, three-phase a.c.
1	2	3	4	5	6	7
(mm^2)	(A)	(A)	(A)	(A)	(A)	(A)
1	16.5	14.5	18	16	19.5	17.5
1.5	21	18.5	23	20	25	22
2.5	29	25	32	28	34	30
4	38	33	43	37	46	40
6	48	43	55	48	59	52
10	66	58	76	66	81	71
16	87	77	103	88	109	94
25	114	100	136	117	144	123
35	139	122	168	144	177	151
50	167	147	201	174	213	186
70	211	185	256	222	272	237
95	254	222	310	269	329	287
120	292	256	359	312	381	333
150	320	287	413	359	438	383
185	368	326	470	409	499	437
240	439	381	553	482	587	515
300	509	436	636	555	675	593

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. Where a conductor operates at a temperature exceeding 70 °C it shall be ascertained that the equipment connected to the conductor is suitable for the conductor operating temperature (see Regulation 512-02).
3. For cables in rigid pvc conduit the values stated in Table 4D2 are applicable (see Regulation 521-05).
4. Where cables in this table are connected to equipment or accessories designed to operate at a temperature rating not exceeding 70 °C, the current ratings given in the equivalent table for 70 °C thermoplastic (pvc) insulated cables (Table 4D2A) shall be used (see also Regulation 523-01-01).

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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