The Open University of Sri Lanka
Diploma in Technology
ECX4234-Electrical Installation
Final Examination 2011/2012

Date 26/02/2012 **Time:9.30-12.30 hrs.**

This paper contains 17 pages with Eight (8) questions. Answer Five (5) questions.

1. a) A delta connected motor is to be started using direct-on line switch. In what range would be the starting current when compared to its full load current? **[3 marks]**
   b) When Star-Delta starting method is used, what would be the range of the starting current when compared to its full load current? **[3 marks]**
   c) A 10 kW motor operating at 0.85 power factor at an efficiency of 95% connected to a 400V, 3 phase supply. A Star-Delta starting method is to be used for this motor. Cables connecting the supply to the starter are single-core; p.v.c. (70^0C) insulated copper conductors running in a conduit. The cables connecting starter to the motor are also single-core, p.v.c. copper conductors and is running in another length of a conduit.
      (i) What is the minimum conductor cross-sectional area for both circuits, if the ambient temperature is 35 ^{0}C? **[10 marks]**
      (ii) Calculate the approximate value of the current flowing between supply and the starter cables while starting? **[4 marks]**

2. The owner of domestic premises to be provided with electrical wiring has the following requirement for the premises:
   - 15 Nos. of fluorescent lamps each controlled by a switch
   - 12 Nos. of incandescent lamps each controlled by a switch
   - 3 Nos. of air-conditioners consuming 16 A at 0.8 p.f. lagging on full load
   - 1 Nos. of electrical heater rated at 2.0 kW
   - 1 Nos. of electric cooker having 3 elements each rated at 1.5 kW and oven rated at 3.0 kW.
   - 1 Nos. of water pump rated at 1.0 kW with a p.f. of 0.85 lag
   - One television consuming 200 Watts
   - 2 Nos. of ring circuits each of capacity 30 A to cater for unspecified appliances.

   (i) Design a suitable electrical distribution system to cater for the requirements of the owner and draw the conceptual single line diagram indicating all the figures on it. Supply to the premises is 3 phase, 415 V (line to line), 50 Hz. **[15 marks]**

   (ii) What is your recommendation for the rating of the current requirement for the premises? Justify your answer. **[5 marks]**

3. A single-phase 230 V circuit is 40 meter long and is installed with 6 mm^2 two-core (with circuit protecting conductor) 70^0C p.v.c. insulated and sheathed cables to BS 6004 having copper conductors. The circuit is protected by a 40 A mcb (type b). Earth fault loop impedance external to the circuit is Z_E=0.35 Ω. Check whether the protection conductor satisfies with the adiabatic equation. Assume k=115) **[20 marks]**

Conductor cross sectional area mm^2		70^0C, p.v.c.insulation
Phase conductor (R_1)	Protective conductor (R_2)	(R_1+R_2)/m, [milli Ohm/meter] for Cu
6	2.5	12.6

4. Figure Q4 shows a metal conduits joined to two sections of metal trunking in an industrial electrical installation. Lengths of each conduit & the conductor sizes are as indicated. Determine:

   (i) An approximate size for the main trunking system A⟶ B and B⟶ C. **[5 marks]**

   (ii) The sizes of conduit for load 1 & 2 **[5 marks]**

   (iii) Maximum number of cables in the conduit for load 3 **[5 marks]**

   (iv) The conduit size for load 4 **[5 marks]**

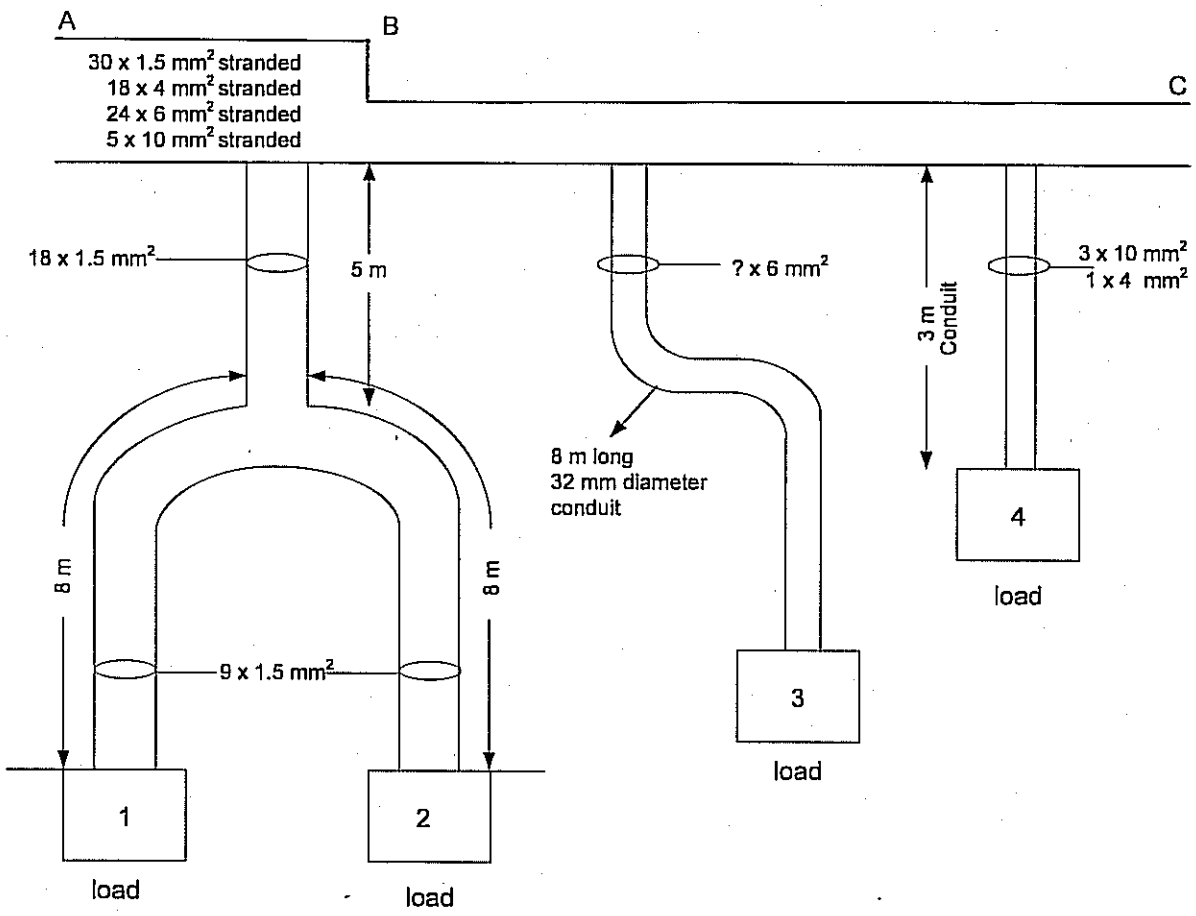


Figure Q4

5. A p.v.c. insulated and sheathed cable of 2.5 mm^2 feeding a 230 V, 3 kW electric cooker protected by a 16 A type B circuit breaker to BS EN 60898 is buried 10 meter along its length directly under the plaster. Due to some fault in the cable, it had to be replaced. The electrician, who carried out the job without burying the new cable of the same size under the wall plaster like the old one, passed it through a conduit which already carries 6 other similar multicore cables.

   Show that what the electrician has done is not safe. Assume suitable values for missing parameters. So what do you recommend him to do? **[20 Marks]**

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, equipment used, expected values, if any (you may use sketches) **[20 Marks]**

7. (a) What is XLPE? Is it thermo setting or thermo plastic? **[5 marks]**
   (b) A single phase 230 V circuit is installed using two-core 25 mm^2 copper conductor, armoured cable having XLPE as insulation to BS 5467. The cable is connected to a load which requires 120 A at a distance of 30 m.
      (i) What would be the voltage drop if the load is operating at 0.8 power factor lagging? **[10 marks]**
      (ii) What would be the voltage drop if the power factor being ignored? **[5 marks]**

8. a) An earth electrode having **r** m radius and l m length is buried in a uniformly distributed soil. The earth resistivity of the soil is given as **ρ** Ωm. Prove that the theoretical value of the resistance of this earth electrode is $\frac{\rho}{2\pi l}\ln\frac{l}{r}$ Ω. State any assumptions made. **[7 marks]**

   Hence compute the resistance offered by an earth electrode with a rod length 2 m, pipe diameter 50 mm and soil resistivity 100 Ωm.? **[3 marks]**

   b) What earthing system would you find in Sri Lanka? State the value of earth resistance that should maintain for a domestic installation in Sri Lanka. **[5 marks]**

   c) Name the rod-arrangement shown in Figure Q8 designed at a construction site for the improvement of earth resistance. What would be the resultant earth resistance if a single rod driven to earth gives an earth resistance of 25 Ohms? **[5 marks]**

   Length of a rod = 2m
   Distance between each rods = 6m

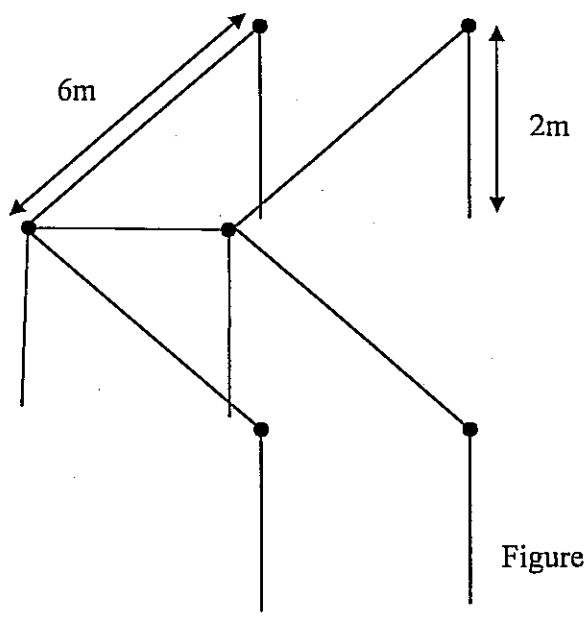


Figure Q8

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)

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

TABLE 4D1B

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

Conductor cross-sectional area	2 cables d.c.	2 cables, single-phase a.c.									3 or 4 cables, three-phase a.c.									
		Reference Methods 3 &4 (enclosed in conduit etc. in or on a wall)			Reference Methods 1 & 11 (clipped direct or on trays, touching)			Reference Method 12 (spaced*)			Reference Methods 3 &4 (enclosed in conduit etc. in or on a wall)			Reference Methods 1, 11 & 12 (in trefoil)			Reference Methods1 &11 (flat and touching)			Reference Method 12 (flat spaced*)		
1	2	3			4			5			6			7			8			9		
(mm^2)	(mV/A/m)	(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)		
1	44	44			44			44			38			38			38			38		
1.5	29	29			29			29			25			25			25			25		
2.5	18	18			18			18			15			15			15			15		
4	11	11			11			11			9.5			9.5			9.5			9.5		
6	7.3	7.3			7.3			7.3			6.4			6.4			6.4			6.4		
10	4.4	4.4			4.4			4.4			3.8			3.8			3.8			3.8		
16	2.8	2.8			2.8			2.8			2.4			2.4			2.4			2.4		
		r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.75	1.80	0.33	1.80	1.75	0.20	1.75	1.75	0.29	1.80	1.50	0.29	1.55	1.50	0.175	1.50	1.50	0.25	1.55	1.50	0.32	1.55
35	1.25	1.30	0.31	1.30	1.25	0.195	1.25	1.25	0.28	1.30	1.10	0.27	1.10	1.10	0.170	1.10	1.10	0.24	1.10	1.10	0.32	1.15
50	0.93	0.95	0.30	1.00	0.93	0.190	0.95	0.93	0.28	0.97	0.81	0.26	0.85	0.80	0.165	0.82	0.80	0.24	0.84	0.80	0.32	0.86
70	0.63	0.65	0.29	0.72	0.63	0.185	0.66	0.63	0.27	0.69	0.56	0.25	0.61	0.55	0.160	0.57	0.55	0.24	0.60	0.55	0.31	0.63
95	0.46	0.49	0.28	0.56	0.47	0.180	0.50	0.47	0.27	0.54	0.42	0.24	0.48	0.41	0.155	0.43	0.41	0.23	0.47	0.40	0.31	0.51
120	0.36	0.39	0.27	0.47	0.37	0.175	0.41	0.37	0.26	0.45	0.33	0.23	0.41	0.32	0.150	0.36	0.32	0.23	0.40	0.32	0.30	0.44
150	0.29	0.31	0.27	0.41	0.30	0.175	0.34	0.29	0.26	0.39	0.27	0.23	0.36	0.26	0.150	0.30	0.26	0.23	0.34	0.26	0.30	0.40
185	0.23	0.25	0.27	0.37	0.24	0.170	0.29	0.24	0.26	0.35	0.22	0.23	0.32	0.21	0.145	0.26	0.21	0.22	0.31	0.21	0.30	0.36
240	0.180	0.195	0.26	0.33	0.185	0.165	0.25	0.185	0.25	0.31	0.17	0.23	0.29	0.160	0.145	0.22	0.160	0.22	0.27	0.160	0.29	0.34
300	0.145	0.160	0.26	0.31	0.150	0.165	0.22	0.150	0.25	0.29	0.14	0.23	0.27	0.130	0.140	0.190	0.130	0.22	0.25	0.130	0.29	0.32
400	0.105	0.130	0.26	0.29	0.120	0.160	0.20	0.115	0.25	0.27	0.12	0.22	0.25	0.105	0.140	0.175	0.105	0.21	0.24	0.100	0.29	0.31
500	0.086	0.110	0.26	0.28	0.098	0.155	0.185	0.093	0.24	0.26	0.10	0.22	0.25	0.086	0.135	0.160	0.086	0.21	0.23	0.081	0.29	0.30
630	0.068	0.094	0.25	0.27	0.081	0.155	0.175	0.076	0.24	0.25	0.08	0.22	0.24	0.072	0.135	0.150	0.072	0.21	0.22	0.066	0.28	0.29
800	0.053		-		0.068	0.150	0.165	0.061	0.24	0.25		-		0.060	0.130	0.145	0.060	0.21	0.22	0.053	0.28	0.29
1000	0.042		-		0.059	0.150	0.160	0.050	0.24	0.24		-		0.052	0.130	0.140	0.052	0.20	0.21	0.044	0.28	0.28

NOTE: * Spacings larger than those specified in Method 12 (see Table 4A1) will result in larger voltage drop.

COPPER CONDUCTORS

TABLE 4E4A
Multicore 90 °C armoured thermosetting insulated cables (COPPER CONDUCTORS)

VOLTAGE DROP (per ampere per metre): Conductor operating temperature: 90 °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)		
1.5	31	31			27		
2.5	19	19			16		
4	12	12			10		
6	7.9	7.9			6.8		
10	4.7	4.7			4.0		
16	2.9	2.9			2.5		
		r	x	z	r	x	z
25	1.85	1.85	0.160	1.90	1.60	0.140	1.65
35	1.35	1.35	0.155	1.35	1.15	0.135	1.15
50	0.98	0.99	0.155	1.00	0.86	0.135	0.87
70	0.67	0.67	0.150	0.69	0.59	0.130	0.60
95	0.49	0.50	0.150	0.52	0.43	0.130	0.45
120	0.39	0.40	0.145	0.42	0.34	0.130	0.37
150	0.31	0.32	0.145	0.35	0.28	0.125	0.30
185	0.25	0.26	0.145	0.29	0.22	0.125	0.26
240	0.195	0.20	0.140	0.24	0.175	0.125	0.21
300	0.155	0.16	0.140	0.21	0.140	0.120	0.185
400	0.120	0.13	0.140	0.190	0.115	0.120	0. 165

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. Where cables in this table are connected to equipment or accessories designed to operate at a temperature not exceeding 70 °C, the current ratings given in the equivalent table for 70 °C thermoplastic (pvc) insulated cables (Table 4D4A) shall be used (see also Regulation 523-01-01).

fig 3.4 Type B circuit-breakers to BS EN 60898 and RCBOs to BS EN 61009

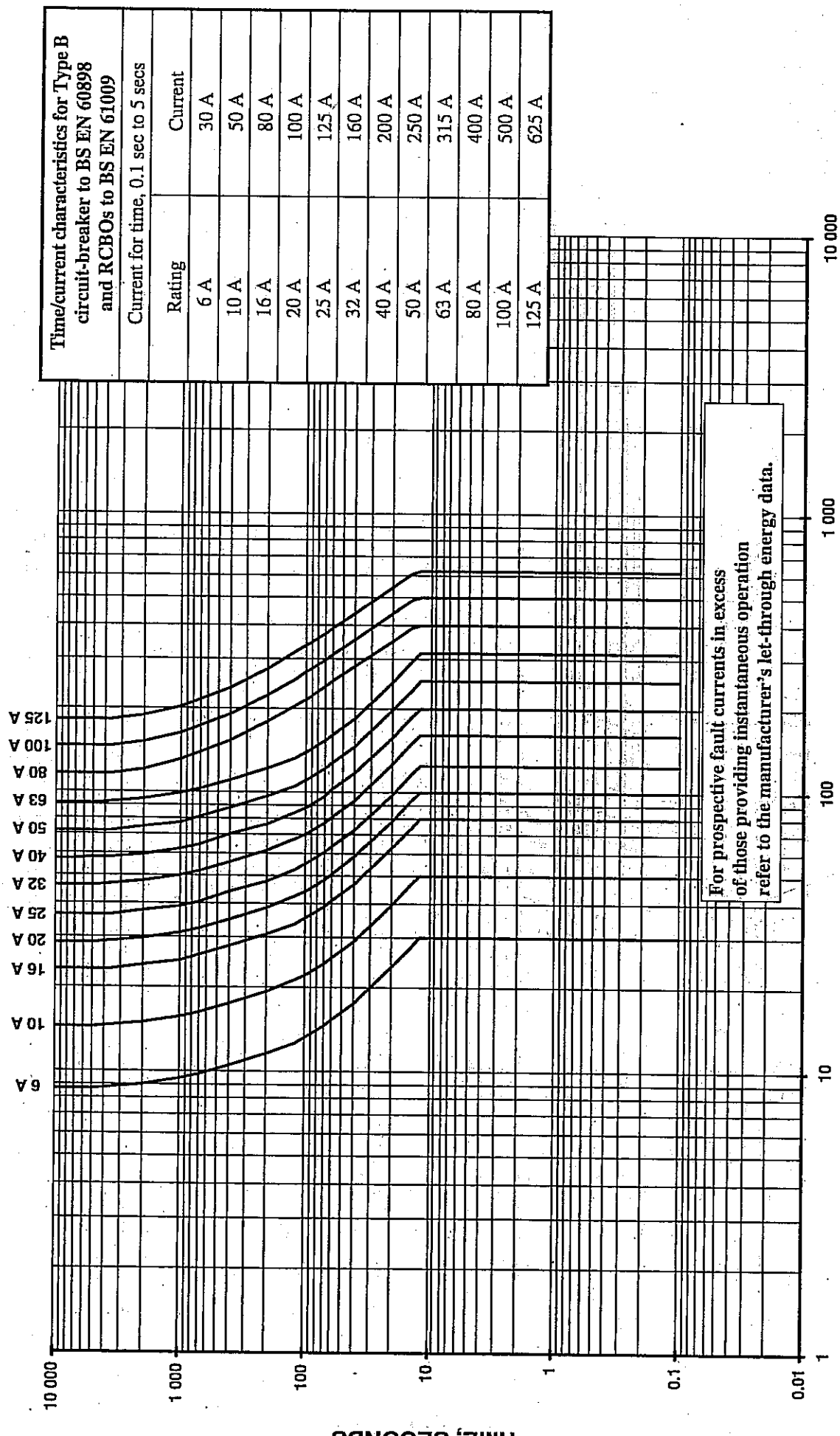
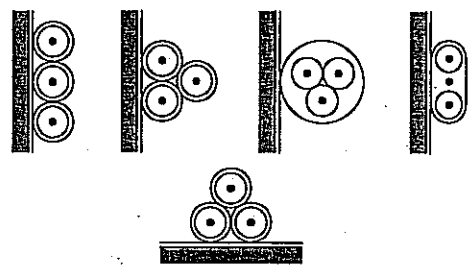
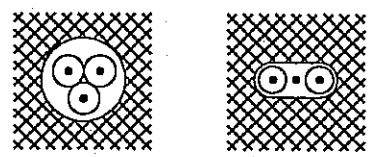
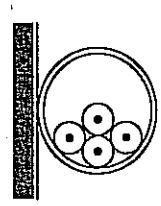
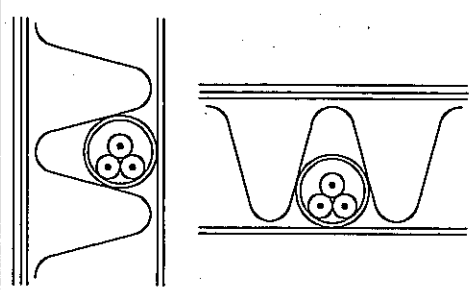
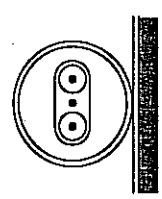


TABLE 4A1
Schedule of Installation Methods of Cables (including Reference Method)

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 4A1 (continued)

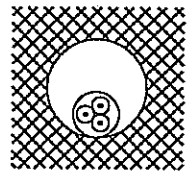
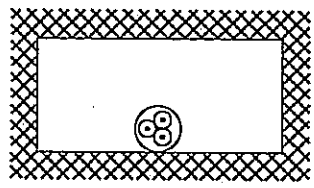
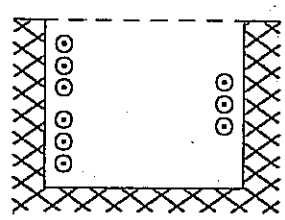
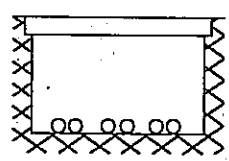
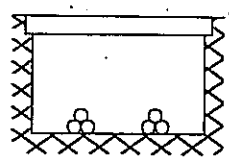
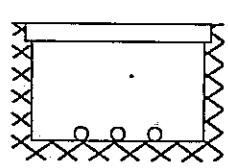
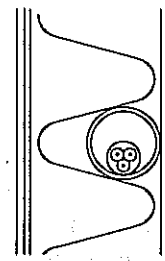
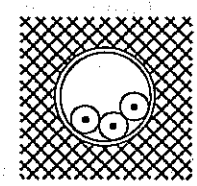
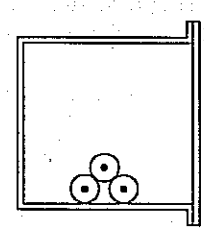
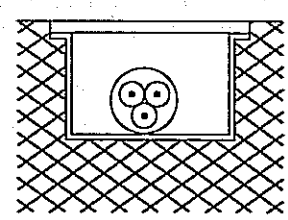
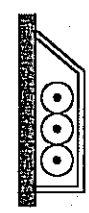
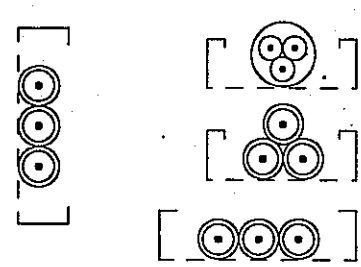
Installation method		Examples	Appropriate Reference Method for determining current-carrying capacity
Number	Description		
1	2	3	4
16	Sheathed cables in ducts or voids formed by the building structure, other than thermally insulating materials	 	Method 4 Where the cable has a diameter D_e and the duct has a diameter not greater than 5 D_e or a perimeter not greater than 20 D_e Method 3 Where the duct has either a diameter greater than 5 D_e or a perimeter greater than 20 D_e NOTE 1 - Where the perimeter is greater than 60 D_e, installation Methods 18 to 20, as appropriate, should be used. NOTE 2 - D_e is the overall cable diameter. For groups of cables D_e is the sum of the cable diameters.
Cables in trenches:			
17	Cables supported on the wall of an open or ventilated trench, with spacings as indicated for Reference Method 12 or 13 as appropriate		Method 12 or 13, as appropriate
18	**Cables in enclosed trench 450 mm wide by 300 mm deep (minimum dimensions) including 100 mm cover**	Two to six single-core cables with surfaces separated by a minimum of one cable diameter.  One or two groups of three single-core cables in trefoil formation.  One to four 2-core cables or one to three 3 or 4 core cables with all cables separated by a minimum of 50 mm 	**Method 18** **Use rating factors in Table 4B3**

TABLE 4A1 (continued)

Installation method		Examples	Appropriate Reference Method for determining current-carrying capacity
Number	Description		
1	2	3	4
6	Sheathed cables in conduit in a thermally insulating wall etc. (otherwise as Reference Method 4)		Method 4 **or** **Method 6 for cable type covered by Table 4D5A.**
7	Cables in conduit embedded in masonry, brickwork, concrete, plaster or the like (other than thermally insulating materials)		Method 3
In trunking:			
8	Cables in trunking on a wall or suspended in the air		Method 3
9	Cables in flush floor trunking		Method 3
10	Single-core cables in skirting trunking		Method 3
On trays:			
11	**Sheathed cables on a perforated cable tray, bunched and unenclosed. A perforated cable tray is a ventilated tray in which the holes occupy 30 % or more of the surface area**		**Method 11**

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.

13 05 17

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					188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5	Covered				182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2	by				177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5	Tables 12A				171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3	and 12B				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 4B

Allowances for diversity

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of premises+		
	Individual household installations, including individual dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Heating and power (but see 3 to 8 below)	100% of total current demand up to 10 amperes + 50% of any current demand in excess of 10 amperes	100% f.l. of largest appliance + 75% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance +60% f.l. of remaining appliances
3. Cooking appliances	10 amperes + 30% f.l. of connected cooking appliances in excess of 10 amperes + 5 amperes if socket-outlet incorporated in unit	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances
4. Motors (other than lift motors which are subject to special consideration)		100% f.l. of largest motor + 80% f.l. of 2nd largest motor + 60% f.l. of remaining motors	100% f.l. of largest motor + 50% f.l. of remaining motors
5. Water-heaters (instantaneous type)*	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances
6. Water-heaters (thermostatically controlled)	no diversity allowable†		
7. Floor warming installations	no diversity allowable†		
8. Thermal storage space heating installations	no diversity allowable†		
9. Standard arrangements of final circuits in accordance with Appendix 5	100% of current demand of largest circuit + 40% of current demand of every other circuit	100% of current demand of largest circuit + 50% of current demand of every other circuit	
10. Socket outlets other than those included in 9 above and stationary equipment other than those listed above	100% of current demand of largest point of utilisation + 40% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every point in main rooms (dining rooms, etc) + 40% of current demand of every other point of utilisation

+ For blocks of residential dwellings, large hotels, large commercial premises, and factories, the allowances are to be assessed by a competent person.

* For the purpose of this Table an instantaneous water-heater is deemed to be a water-heater of any loading which heats water only while the tap is turned on and therefore uses electricity intermittently.

† It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.