Technical Guide

CONTENTS

Table A Conversion Factors

Length:	1 inch	=	25.4 millimetres (mm)
	1 foot	=	304.8 mm
	1 yard	=	0.9144 metre (m)
	1 mile	=	1.609 kilometre (km)
	1 mm	=	0.039 inch
	1 m	=	1.094 yard
	1 km	=	0.621 mile
	1 mil	=	0.0254 mm
	1 micron	=	0.001 mm
Area:	1 $inch^2$	=	645.16 square millimetres (mm^2)
	1 $foot^2$	=	0.093 square metre (m^2)
	1 $yard^2$	=	0.836 m^2
	1 mm^2	=	0.0015 $inch^2$
	1 m^2	=	1.196 $yard^2$
	1 circ mil	=	0.00050671 mm^2
	1 acre	=	4046.86 m^2
Volume:	1 $inch^3$	=	16387.1 mm^3
	1 $foot^3$	=	0.0283 m^3
	1 cm^3	=	0.061 $inch^3$
	1 m^3	=	35.315 $foot^3$
	1 $inch^3$	=	0.01639 litres
	1 gallon	=	4.546 litres
	1 litre	=	0.264 US gallons
Weight:	1 lb	=	0.454 kg
	1 ton	=	1016 kg
	1 kg	=	2.2046 lbs
Density:	1 $lb/inch^3$	=	$2.768X10^4$ kg/m^3
			27.68 gm/cm^3 or gm/ml
	1 lb/ft^3	=	16.019 kg/m^3
			0.016 gm/cm^3 or gm/ml
	1 kg/m^3	=	0.0624 lb/ft^3
	1 $tonne/m^3$	=	62.43 lb/ft^3

Force:	1 lbf (pound force)	=	4.448 newtons (N)
	1 N	=	0.225 lbf
			0.102 kgf
	1 kgf	=	9.80665 kg.m/s²
		=	9.80665 N
Pressure:	1 lbf/inch²	=	6.895 kN/m²
	1 kN/m²	=	0.145 lbf/inch²
	1 MN/m²	=	0.102 kg/mm²
	1 Pa (paskal)	=	1 N/m²
	1 pz (pieze)	=	1 k Pa
	1 dyn/cm²	=	0.1 Pa
	1 bar	=	10^5 Pa
		=	1.01972 kgf/cm²
	1 bar	=	14.5 psi
		=	0.986923 atm
		=	750.062 torr
Linear Velocity (speed):	1 ft/sec	=	0.3048 m/s
	1 mile/hr	=	0.447 m/s
		=	1.609 km/h
	1 m/s	=	3.281 ft/sec
		=	2.237 mile/hr
	1 km/hr	=	0.621 mile/hr
Angular Velocity:	1 rad/s	=	0.159155 rev/s
	1 rev/s	=	360 degree/s
Power:	1 Hp	=	745.70 Watts
		=	33000 foot pounds per minute
		=	550 foot pounds per second
	1 kW	=	1.34 Hp
Energy:	1 ft.lbf	=	1.356 joules (J)
	1 kW.hr	=	3.60 Mega joules (MJ)
	1 joule	=	0.738 ft.lbf
		=	9.478×10^{-4} Btu
	1 MJ	=	0.278 kW.hr

Table B Properties of metals used in cables

Properties	Unit	Annealed copper	Aluminum	Steel	Aluminum Alloy
Density	g/cm^3	8.89	2.703	7.78	2.703
Young's Modules of Elasticity	N/mm^2	100 000	68 000	207 000	68 000
Co-efficient of linear expansion	Deg. C	$17X10^{-6}$	$23X10^{-6}$	$11.5X10^{-6}$	$23X10^{-6}$
Elecrical resistivity	$\Omega.mm^2/km$	17.241	28.264	138	32.53
Temp. co-efficient of resistance at 20 °C	Per deg. C	0.00393	0.00403	0.0045	0.0036
Conductvity (% IACS)	-	≥100	≥61	-	≥53

Table C Performance and selection of commonly used thermoplastic and thermosetting cables insulating and sheathing materials

Material	General purpose PVC insulation	Heat resisting PVC insulation	Special heat resisting PVC insulation	Cross linked polyethlyene XLPE insulation	General purpose PVC sheathing	Heat resistance PVC sheathing
Max. conductor temp. for continuous operation °C	70	85	105	90	70	90
Max. conductor temp. at the termination of short circuit °C	160	160	160	250	160	160
Min. working temp. °C	-20	-15	-30	-40	-20	-15
Resistance to :						
Ozone	E	E	E	G	E	E
Corona	E	E	E	P	E	E
Weather	G	G	G	G	G	G
Oil	G	G	G	G	G	G
Water	G	G	G	G	G	G
Chemical	G	G	G	G	G	G
Solvents	F	F	F	G	F	F
Abrasions	G	E	E	G	G	E
Flame resistance	E	E	E	P	E	E
Electricals:						
Insulation resistance	G	E	E	E	NA	NA
Voltage breakdown	G	G	G	E	NA	NA
A.C. Losses	F	F	F	E	NA	NA

E-EXCELLENT G-GOOD F-FAIR P-POOR NA-NOT APPLICABLE

1. General view of low voltage power cables

A general view of the components of cables with rating voltage of 1KV is introduced in this section, also the criteria of selection of power cable is included.

1.1 Component Details

Conductor

Conductors are made from copper and Aluminum material. Depending on the use of the cable, conductors are divided to solid (Class 1) for smaller sizes, stranded (Class 2) for fixed installation and Flexible (Class 5) for flexible installation, as per IEC 60228 and BS EN 60228.

Stranded conductors may be one of the three following shapes:

1. Round Non-compacted
2. Round compacted
3. Sector shaped
   - For more information about conductor materials see Table B

Insulation

The insulation materials used in our cables are as following:

1. PVC (Polyvinyl Chloride), material and thickness are as per IEC 60502-1 or BS 6436, PVC material as per IEC 60502-1 is Type A and as per BS EN 50363 is TI1. Good Insulation material with flexibility characteristic.

2. XLPE (Cross-linked Polyethylene), material and thickness are as per IEC 60502-1 or BS 5467 suitable for maximum conductor temperature 90°C during normal operation. Excellent insulation material with higher dielectric characteristic.
   - For more information about insulation materials see Table C

Core Assembly

The cores are laid up and the interstices filled with a non-hygroscopic material where necessary to achieve a circular cable. The laid up cores may be bound with helically applied non-hygroscopic tapes. As per Middle East widely spread color coding our color coding is,

1. Core: Red or Black
2. Core: Red and Black
3. Core: Red, Yellow and Blue
4. Core: Red, Yellow, Blue and Black
5. Core: Red, Yellow, Blue, Black and Green
   - Color code as per BS standards may be given on request.

Inner sheath (Bedding)

Inner sheath is provided as extruded layer of PVC material over the laid up cores. It is required in the case of armored cables to provide bedding for the armoring layer. It may be omitted in case of unarmored cables.

Armoring

Generally galvanized steel wire armoring is provided over the inner sheath in multi-core cables. In case of single core armored cables, the material for armoring shall be non-magnetic.

Outer Sheath

The outer sheath consists of a thermoplastic compound; the sheathing material shall be suitable for the operating temperature of cables. Material of sheathing is PVC ST2 as per IEC 60502-1, PVC Type 9 as per BS 5467 and TM1 as per BS 6346.

On request halogen free sheathing material may be used on cables which are required to be reduced flame spread, low level of smoke emission and halogen free spread gas emission when exposed to fire. Chemical additives may also used on request for termite protection.

- For more information about sheathing materials see Table C

1.2 Criteria for the selection of power cables

The electrical current in a conductor causes a voltage drop and power losses. The temperature rise in the cable caused by the losses must be kept within certain limits in order not to shorten the service life of the cable. The temperature limit varies with the type of cable, or more precisely the type of insulation. The best way to keep the temperature within limits specified for the type of cable is to choose the conductor cross-section so that the cable and its surroundings with the actual continuous load achieve thermal balance at a temperature below or equal to the temperature limit recommended.

Factors of interest for the cable choice:

1. Application
2. Working voltage
3. Load current, load factor and frequency
4. Installation method
5. The environment in which the cable has to operate
6. Short circuit current and system protection
7. Acceptable voltage drop
8. Economics

How the above factors influence on the choice of cable?

1) The application of the cable determines the basic factors for the choice of cable type and the rules according to which it must be manufactured. Following are the major factors for choice of cable type.

   a) Conductor material: No doubt that copper is the best material owing to its high electrical conductivity and other electrical/mechanical properties but to its high cost and scarcity, researches are being carried out to find other cheaper and abundant metal which may be a close substitute to copper in electrical application. Aluminum conductors are being used in place of copper conductors for the past many years and have proved to be quite satisfactory.

      The lower conductivity of aluminum (61% of the annealed copper) results increased dimensions of the cable and ultimately of conduits and fittings for the same current carrying capacity as that of a copper conductor cable. Aluminum conductor cables although bigger and somewhat stiffer when lower number of wires is used for the conductor than the equivalent copper conductor cables, are still flexible enough to be installed where the lighter weight offset the disadvantages of large sizes for a given capacity. The use of flexible copper conductor is recommended where very high degree of flexibility is required.

   b) Insulating materials: The right type of insulating material for a particular usage depends upon the voltage grade, operating temperature required, degree of flexibility, current capacity requirement and restrictions on size etc. and other climatic conditions.

   c) Armoring: The purpose of armor is to provide mechanical protection to the cable and to facilitate earthing for safety requirements. This also carries phase to ground fault currents of the system safely.

      Double steel tape provides good mechanical protection but when in addition longitudinal stresses are encountered during the installation or in service, steel wire armoring is preferred.

2) The system voltage determines the voltage class of the cable.

3) The current rating is in general the decisive factor for fixing conductor cross section. But in certain applications where intermittent load is required, it is more relevant to use the average r.m.s current with a reduced cross-section.

4) The power cables must be capable of carrying the required normal full load current continuously under the site conditions throughout the year. Therefore the current rating specified must be corrected to site conditions by applying suitable de-rating factor depending upon,

   a) Ground or ambient air temperature (max.)
   b) Thermal resistivity of soil during dry season
   c) Depth of laying
   d) Total number of cable/circuit in groups

   Current rating for cables laid in pipes, the stated maximum continuous rating in ground is to be multiplied by the factor 0.8 (approximate).

5) a) Chemical substance in the environment might cause special stringent requirements on the outer covering.
   b) If it is required or necessary to reduce the propagation of fire along cable route combined with low corrosivity, toxicity and smoke generation characteristics for cables, "FRLS" cables (Flame retardant low smoke) with thermoplastic or thermosetting material should be used. These types of cables are designed with special composition of protective sheath materials for use in such fire risk installations.

6) Short circuit current together with duration of short circuit determines the short circuit energy, the cable insulation has to withstand thermally. In certain cases a larger size of cable than the cable required for normal full load current may be needed to match system short circuit current level.

7) There is again another major factor in deciding the size of the cable is voltage drop.

8) Naturally, the most economical construction and the size of the cable consistent with required current carrying capacity and laying condition has to be selected. Thus the selection of particular type of cable i.e. PVC or XLPE and the particular material of sheathing, bedding and armoring. The design of the cable for a particular application must be optimized taking into account all the above mentioned factors.

2. Voltage designation

Designation of voltage of a cable determines the type, material and dimensions of insulation. In this catalogue below are the designation voltages of our power cables products.

The rated voltages Uo/U (Um) of the cables considered in this catalogue are as following:

The cable rated voltage between each conductor and earth or metallic cover (Uo), is 0.6 KV, the cable rated voltage between phase conductors in a three-phase system (U), is 1.0 KV, the highest system voltage (Um), is 1.2 KV

3. current carrying capacity

Elaborately this section is divided in two clauses and then tabulated; clause 3.1 installation in air and clause 3.2 installation underground.

3.1 Installation In Air

3.1.1 Installation conditions

The values are based on installation in free air with unhindered heat dissipation by radiation and convection and with the exclusion of external heat source in an ambient air temperature which does not rise significantly.

The values given in Table 3.1 are based on temperature of 30^{o}C. For other air temperatures Table 3.4 shall be used to find the temperature rating factor, (refer to equation 3.1).

3.1.2 Cable arrangement

Methods of installation are clearly shown with the drawings and arrangements in Table 3.2 and Table 3.3 with the calculated rating factors, (refer to equation 3.1).

3.1.3 Insulation material

Insulation materials are PVC and XLPE, the maximum conductor temperature in case of PVC is 70^{o}C and 90^{o}C for XLPE.

3.1.4 Calculation of Current Carrying Capacity

To calculate the current carrying capacity of a cable, follow below equation,

$$Iz = It \times F1 \times F2 \qquad (3.1)$$

Iz: Current Carrying Capacity in Ampere
It: Tabulated load Capacity (table 3.1)
F1: Grouping factor (table 3.2 or table 3.3)
F2: Temperature factor (table 3.4)

3.2 Installation Underground

3.2.1 Installation conditions

The depth of lay of cable in ground is generally taken as 0.7 meter which is the distance below the ground surface to the axis of the cable. No factor is required when the depth of lay varies within the range of (0.7 to 1.2) meter.

The ground temperature is taken as the temperature at installation depth with the cable no load conditions. The values given in Table 3.5 are based on ground temperature of 20°C.

Soil thermal resistivity of 2.5 Km/W was selected for dry area in this catalogue.

Soil thermal resistivity Recommended values to IEC 287

Weather conditions	*Ground conditions*	*Soil thermal resistivity Km/W*
Continuously moist	*Very moist*	*0.7*
Regular rainfall	*Moist*	*1.0*
Seldom rains	*Dry*	*2.0*
Little or no rains	*Very dry*	*3.0*

Rating factors for the above installation conditions are taken from Table 3.6 (refer to equation 3.2).

3.2.2 Insulation material

Refer to clause 3.1.3

3.2.3 Cable arrangement

Methods of installation are clearly shown with the drawings and in Tables from 3.7 to Table 3.15 with the calculated rating factors. (Refer to equation 3.2).

3.2.4 Calculation of Current Carrying Capacity

To calculate the current carrying capacity of a cable, follow below equation,

$$Iz = It \times F1 \times F2 \qquad (3.2)$$

Iz: Current Carrying Capacity in Ampere
It: Tabulated load Capacity (table 3.5)
F1: Conditions rating factor F 1 (table 3.6)
F2: Grouping rating factor F2 (table 3.7 - table 3.11) for PVC insulation (table 3.12 - table 3.15) for XLPE insulation

Installation arrangements

Single core Cable

Multi-core/ Two Core Cable

Multi-core/ Three Core Cable

Multi-core/ Four Core Cable

Single Core (Trefoil formation)

Single Core (Flat formation)

Table 3.1 Load Capacity in Ampere (installed in air)

Copper

	PVC					XLPE			
size mm^2	Single in D.C	Two core cable	3/4 core cable in 3-Phase	Single core trefoil	single core flat	Single in D.C	3/4 core cable in 3-phase	Single core trefoil	single core flat
1.5	26	20	18.5	20	25	32	24	25	32
2.5	35	27	25	27	34	43	32	34	42
4	46	37	34	37	45	57	42	44	56
6	58	48	43	48	57	72	53	57	71
10	79	66	60	66	78	99	73	77	96
16	105	89	80	89	103	131	96	102	128
25	140	118	106	118	137	177	130	139	173
35	174	145	131	145	169	218	160	170	212
50	212	176	159	176	206	266	195	208	258
70	269	224	202	224	261	338	247	265	328
95	331	271	244	271	321	416	305	326	404
120	386	314	282	314	374	487	355	381	471
150	442	361	324	361	428	559	407	438	541
185	511	412	371	412	494	648	469	507	626
240	612	484	436	484	590	779	551	606	749
300	707	-	481	549	678	902	638	697	864
400	859	-	560	657	817	1070	746	816	1018
500	1000	-	-	749	940	1246	-	933	1173

Aluminum

	PVC					XLPE			
size mm^2	Single in D.C	Two core cable	3/4 core cable	Single core trefoil	single core flat	Single in D.C	3/4 core cable	Single core trefoil	single core flat
25	128	91	83	-	-	137	100	-	-
35	145	113	102	113	131	168	122	131	163
50	176	138	124	138	160	206	147	161	200
70	224	174	158	174	202	262	189	205	254
95	271	210	190	210	249	323	232	253	313
120	314	244	221	244	291	377	270	296	366
150	361	281	252	281	333	433	308	341	420
185	412	320	289	320	384	502	357	395	486
240	484	378	339	378	460	605	435	475	585
300	548	-	377	433	530	699	501	548	675
400	666	-	444	523	642	830	592	647	798
500	776	-	-	603	744	966	-	749	926
F1	Table 3.3			Table 3.2		Table 3.3		Table 3.2	
F2	Table 3.4					Table 3.4			

Table 3.2-a Rating factor F1 (group in air) Single-core cable in 3-phase systems

Arrangement of cables	Nmber of cable trays or cable racks	Installed in one plane Clearance = cable diameter *d* distance from wall ≥ 2cm				Installation in bunches Clearance = 2*d* distance from wall ≥ 2cm			
		Number of systems			Reference Arrangement	Number of systems			Reference Arrangement
		1	2	3		1	2	3	
On the floor	-	0.92	0.89	0.88	A	0.95	0.90	0.88	E
On cable trays	1	0.92	0.89	0.88	B	0.95	0.90	0.88	F
	2	0.87	0.84	0.83		0.90	0.85	0.83	
	3	0.84	0.82	0.81		0.88	0.83	0.81	
	6	0.82	0.80	0.79		0.86	0.81	0.79	
On cable racks	1	1.00	0.97	0.96	B	1.00	0.98	0.96	F
	2	0.97	0.94	0.93		1.00	0.95	0.93	
	3	0.96	0.93	0.92		1.00	0.94	0.92	
	6	0.94	0.91	0.90		1.00	0.93	0.90	
On supports or on the wall	-	0.94	0.91	0.89	C	0.89	0.86	0.84	D
Arrangement for which a reduction is not required		In installations in one plane with increased clearance the increased sheath or screen losses counteract the otherwise reduced temperature rise. therefore indications as to reduction-free arrangement cannot be made here.				H			

Table 3.2-b Arrangement reference and drawings (continue of Table 3.2-a)

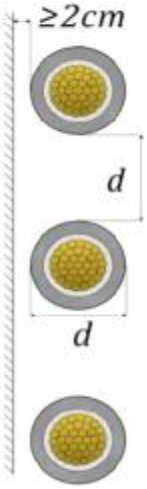
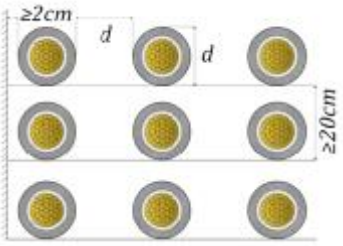
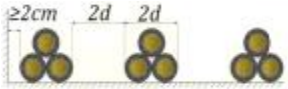
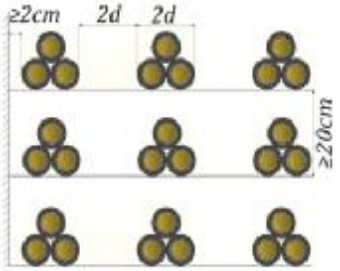
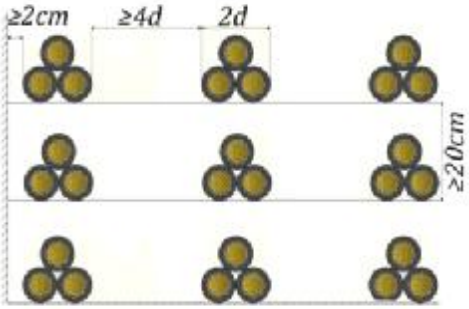
Reference No.	Arrangement	Reference No.	Arrangement	Reference No.	Arrangement
A		C		D	
B					
E					
F		H			

Table 3.3-a Rating factor F1 (group in air) Multi-core cables & Single core in D.C

Arrangement of cables	Nmber of cable trays or cable racks	Installed in one plane Clearance = cable diameter d distance from wall ≥ 2cm						Installation in bunches Clearance= 2*d* distance from wall ≥ 2cm					
		Number of Systems					Reference Arrangement	Number of Systems					Reference Arrangement
		1	2	3	6	9		1	2	3	6	9	
On the floor	-	0.95	0.90	0.88	0.85	0.84	A	0.90	0.84	0.80	0.75	0.73	E
on cable trays	1	0.95	0.90	0.88	0.85	0.84	B	0.95	0.84	0.80	0.75	0.73	F
	2	0.90	0.85	0.83	0.81	0.80		0.95	0.80	0.76	0.71	0.69	
	3	0.88	0.83	0.81	0.79	0.78		0.95	0.78	0.74	0.70	0.68	
	6	0.86	0.81	0.79	0.77	0.76		0.95	0.76	0.72	0.68	0.66	
on cable racks	1	1.00	0.98	0.96	0.93	0.92	B	0.95	0.84	0.80	0.75	0.73	F
	2	1.00	0.95	0.93	0.90	0.89		0.95	0.80	0.76	0.71	0.69	
	3	1.00	0.94	0.92	0.89	0.88		0.95	0.78	0.74	0.70	0.68	
	6	1.00	0.93	0.90	0.87	0.86		0.95	0.76	0.72	0.68	0.66	
On supports or on the wall	-	1.00	0.93	0.90	0.87	0.86	C	0.95	0.78	0.73	0.68	0.66	G
Arrangement for which a reduction is not required		Number of cables arranged above each other is not restricted					D	Number of cables arranged side by side is not restricted					H

Table 3.3-b Arrangement reference and drawings (continue of Table 3.3-a)

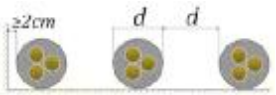
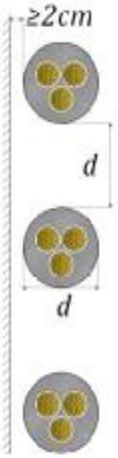
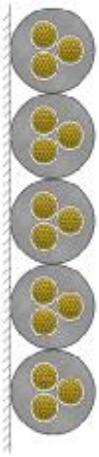
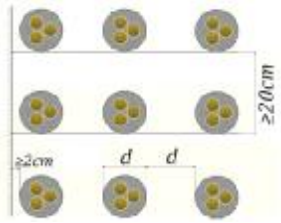
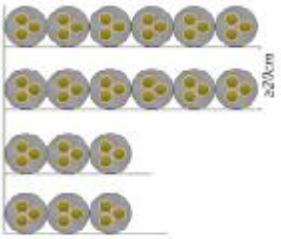
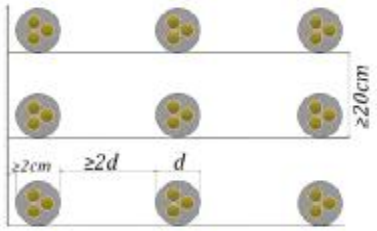
Reference No.	Arrangement	Reference No.	Arrangement	Reference No.	Arrangement	Reference No.	Arrangement
A		C		D		G	
B							
E							
F		H					

Table 3.4 Rating factors F2 for differing air temperature

Type of Insulation	Permissible conductor temp. °C	Air Temp. °C								
		10	15	20	25	30	35	40	45	50
XLPE	90	1.15	1.12	1.08	1.04	1.00	0.96	0.91	0.87	0.82
PVC	70	1.22	1.17	1.12	1.06	1.00	0.94	0.87	0.79	0.71

Table 3.5 Load Capacity in Ampere (installed in ground)

Copper

	PVC					XLPE			
size mm^2	Single in D.C	Two core cable	3/4 core cable in 3-phase	Single core trefoil	single core flat	Single in D.C	3/4 core cable in 3-phase	Single core trefoil	single core flat
1.5	40	32	26	-	-	48	30	32	39
2.5	54	42	34	-	-	63	40	43	51
4	70	54	44	-	-	82	52	55	66
6	90	68	56	-	-	103	64	68	82
10	122	90	75	-	-	137	86	90	109
16	160	116	98	107	127	177	111	115	139
25	206	-	128	137	163	229	143	149	179
35	249	-	157	165	195	275	173	178	213
50	296	-	185	195	230	327	205	211	251
70	365	-	228	239	282	402	252	259	307
95	438	-	275	287	336	482	303	310	366
120	499	-	313	326	382	550	346	352	416
150	561	-	353	366	428	618	390	396	465
185	637	-	399	414	483	701	441	449	526
240	743	-	464	481	561	819	511	521	610
300	843	-	524	542	632	931	580	587	689
400	986	-	600	624	730	1073	663	669	788
500	1125	-	-	698	823	1223	-	748	889

Aluminum

	PVC					XLPE			
size mm^2	Single in D.C	Two core cable	3/4 core cable	Single core trefoil	single core flat	Single in D.C	3/4 core cable	Single core trefoil	single core flat
25	-	-	99	-	-	177	111	-	-
35	192	-	118	127	151	212	132	137	164
50	229	-	142	151	179	253	157	163	195
70	282	-	176	186	218	311	195	201	238
95	339	-	211	223	261	374	233	240	284
120	388	-	242	254	297	427	266	274	323
150	435	-	270	285	332	479	299	308	361
185	494	-	308	323	376	543	340	350	408
240	578	-	363	378	437	637	401	408	476
300	654	-	412	427	494	721	455	462	537
400	765	-	475	496	572	832	526	531	616
500	873	-	-	562	649	949	-	601	699
F1	From Table 3.6					From Table 3.6			
F2	Table (3.9 or 3.15)	Table 3.11	Table (3.9 or 3.15)	Table (3.7, 3.8, 3.12 or 3.13)	Table (3.10 or 3.14)	Table (3.9 or 3.15)		Table (3.7, 3.8, 3.12 or 3.13)	Table (3.10 or 3.14)

Table 3.6 Rating factor F1 (installed in ground)

Permissible Conductor Temp. °C	Ground Temp. °C	Soil-thermal resistivity 0.7 Km/W Load factor					1.0 Km/W Load factor					1.5 Km/W Load factor					2.5 Km/W Load factor
		0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.5 to 1.0
90	5	1.24	1.21	1.18	1.13	1.07	1.11	1.09	1.07	1.03	1.00	0.99	0.98	0.97	0.96	0.94	0.89
	10	1.23	1.19	1.16	1.11	1.05	1.09	1.07	1.05	1.01	0.98	0.97	0.96	0.95	0.93	0.91	0.86
	15	1.21	1.17	1.14	1.08	1.03	1.07	1.05	1.02	0.99	0.95	0.95	0.93	0.92	0.91	0.89	0.84
	20	1.19	1.15	1.12	1.06	1.00	1.05	1.02	1.00	0.96	0.93	0.92	0.91	0.90	0.88	0.86	0.81
	25	-	-	-	-	-	1.02	1.00	0.98	0.94	0.90	0.90	0.88	0.87	0.85	0.84	0.78
	30	-	-	-	-	-	-	-	0.95	0.91	0.88	0.87	0.86	0.84	0.83	0.81	0.75
	35	-	-	-	-	-	-	-	-	-	-	-	-	0.82	0.80	0.78	0.72
	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.68
80	5	1.27	1.23	1.20	1.14	1.08	1.12	1.10	1.07	1.04	1.00	0.99	0.98	0.97	0.95	0.93	0.88
	10	1.25	1.21	1.17	1.12	1.06	1.10	1.07	1.05	1.01	0.97	0.97	0.95	0.94	0.92	0.91	0.85
	15	1.23	1.19	1.15	1.09	1.03	1.07	1.05	1.03	0.99	0.95	0.94	0.93	0.92	0.90	0.88	0.82
	20	1.20	1.17	1.13	1.07	1.01	1.05	1.03	1.00	0.96	0.92	0.91	0.90	0.89	0.87	0.85	0.78
	25	-	-	-	-	-	1.03	1.00	0.97	0.93	0.89	0.88	0.87	0.86	0.84	0.82	0.75
	30	-	-	-	-	-	-	-	0.95	0.91	0.86	0.85	0.84	0.83	0.81	0.78	0.72
	35	-	-	-	-	-	-	-	-	-	-	-	-	0.80	0.77	0.75	0.68
	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.64
70	5	1.29	1.26	1.22	1.15	1.09	1.13	1.11	1.08	1.04	1.00	0.99	0.98	0.97	0.95	0.93	0.86
	10	1.27	1.23	1.19	1.13	1.06	1.11	1.08	1.06	1.01	0.97	0.96	0.95	0.94	0.92	0.89	0.83
	15	1.25	1.21	1.17	1.10	1.03	1.08	1.06	1.03	0.99	0.94	0.93	0.92	0.91	0.88	0.86	0.79
	20	1.23	1.18	1.14	1.08	1.01	1.06	1.03	1.00	0.96	0.91	0.90	0.89	0.87	0.85	0.83	0.76
	25	-	-	-	-	-	1.03	1.00	0.97	0.93	0.88	0.87	0.85	0.84	0.82	0.79	0.72
	30	-	-	-	-	-	-	-	0.94	0.89	0.85	0.84	0.82	0.80	0.78	0.76	0.68
	35	-	-	-	-	-	-	-	-	-	-	-	-	0.77	0.74	0.72	0.63
	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59

Table 3.7 Rating factor F2 (installed in ground) for PVC insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.01	1.02	0.99	0.93	0.87	1.04	1.05	1.00	0.93	0.87	1.07	1.06	1.01	0.94	0.87	1.11	1.08	1.01	0.94	0.87
2	0.94	0.89	0.84	0.77	0.71	0.97	0.91	0.85	0.77	0.71	0.99	0.92	0.86	0.77	0.71	1.01	0.93	0.87	0.78	0.71
3	0.86	0.79	0.74	0.67	0.61	0.89	0.81	0.75	0.67	0.61	0.90	0.83	0.76	0.68	0.61	0.91	0.83	0.77	0.68	0.61
4	0.82	0.75	0.69	0.62	0.56	0.84	0.76	0.70	0.62	0.56	0.85	0.77	0.71	0.62	0.56	0.86	0.78	0.71	0.63	0.56
5	0.78	0.71	0.65	0.58	0.52	0.80	0.72	0.66	0.58	0.52	0.80	0.73	0.66	0.58	0.52	0.81	0.73	0.67	0.59	0.52
6	0.75	0.68	0.62	0.55	0.50	0.77	0.69	0.63	0.55	0.50	0.77	0.70	0.64	0.56	0.50	0.78	0.70	0.64	0.56	0.50
8	0.71	0.64	0.58	0.51	0.46	0.72	0.65	0.59	0.52	0.46	0.73	0.65	0.59	0.52	0.46	0.73	0.66	0.60	0.52	0.46
10	0.68	0.61	0.55	0.49	0.44	0.69	0.62	0.56	0.49	0.44	0.69	0.62	0.56	0.49	0.44	0.70	0.63	0.57	0.49	0.44

Table 3.8 Rating factor F2 (installed in ground) for PVC insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.01	1.02	0.99	0.93	0.87	1.04	1.05	1.00	0.93	0.87	1.07	1.06	1.01	0.94	0.87	1.11	1.08	1.01	0.94	0.87
2	0.97	0.95	0.89	0.82	0.75	1.00	0.96	0.90	0.82	0.75	1.03	0.97	0.91	0.82	0.75	1.06	0.98	0.92	0.83	0.75
3	0.94	0.88	0.82	0.74	0.67	0.97	0.88	0.82	0.74	0.67	0.97	0.89	0.83	0.74	0.67	0.98	0.90	0.84	0.74	0.67
4	0.91	0.84	0.78	0.70	0.64	0.92	0.85	0.79	0.70	0.64	0.93	0.86	0.79	0.70	0.64	0.95	0.87	0.80	0.71	0.64
5	0.88	0.81	0.75	0.67	0.60	0.89	0.82	0.76	0.67	0.60	0.90	0.82	0.76	0.67	0.60	0.91	0.83	0.77	0.67	0.60
6	0.86	0.79	0.73	0.65	0.59	0.87	0.80	0.74	0.65	0.59	0.88	0.81	0.74	0.65	0.59	0.89	0.81	0.75	0.65	0.59
8	0.83	0.76	0.70	0.62	0.56	0.84	0.77	0.71	0.62	0.56	0.85	0.78	0.71	0.62	0.56	0.86	0.78	0.72	0.62	0.56
10	0.82	0.75	0.69	0.60	0.54	0.82	0.75	0.69	0.60	0.54	0.83	0.76	0.69	0.61	0.54	0.84	0.76	0.70	0.61	0.54

Table 3.9 Rating factor F2 (installed in ground) for PVC insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	0.91	0.92	0.94	0.94	0.89	0.97	0.97	1.00	0.94	0.89	1.04	1.03	1.01	0.94	0.89	1.13	1.07	1.02	0.95	0.89
2	0.86	0.87	0.85	0.77	0.72	0.91	0.90	0.86	0.78	0.72	0.97	0.93	0.87	0.78	0.72	1.01	0.94	0.88	0.79	0.72
3	0.82	0.80	0.75	0.68	0.62	0.86	0.82	0.76	0.68	0.62	0.91	0.84	0.77	0.69	0.62	0.92	0.84	0.78	0.69	0.62
4	0.80	0.76	0.70	0.63	0.57	0.84	0.77	0.71	0.63	0.57	0.86	0.78	0.72	0.63	0.57	0.87	0.79	0.73	0.64	0.57
5	0.78	0.72	0.66	0.59	0.53	0.81	0.73	0.67	0.59	0.53	0.81	0.74	0.68	0.59	0.53	0.82	0.75	0.68	0.60	0.53
6	0.76	0.69	0.64	0.56	0.51	0.77	0.70	0.64	0.56	0.51	0.78	0.71	0.65	0.57	0.51	0.79	0.72	0.65	0.57	0.51
8	0.72	0.65	0.59	0.52	0.47	0.73	0.66	0.60	0.52	0.47	0.74	0.67	0.61	0.52	0.47	0.75	0.67	0.61	0.53	0.47
10	0.69	0.62	0.57	0.49	0.44	0.70	0.63	0.57	0.50	0.44	0.71	0.64	0.58	0.50	0.44	0.71	0.64	0.58	0.50	0.44

Table 3.10 Rating factor F2 (installed in ground) for PVC insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	0.96	0.97	0.98	0.91	0.85	1.01	1.01	1.00	0.92	0.85	1.07	1.05	1.01	0.92	0.85	1.16	1.10	1.02	0.93	0.85
2	0.92	0.89	0.86	0.77	0.71	0.96	0.94	0.87	0.78	0.71	1.00	0.95	0.88	0.78	0.71	1.05	0.97	0.89	0.79	0.71
3	0.88	0.84	0.77	0.69	0.62	0.91	0.85	0.78	0.69	0.62	0.95	0.86	0.79	0.69	0.62	0.96	0.87	0.79	0.69	0.62
4	0.86	0.80	0.73	0.65	0.58	0.89	0.81	0.74	0.65	0.58	0.90	0.82	0.74	0.65	0.58	0.91	0.82	0.75	0.65	0.58
5	0.84	0.76	0.70	0.61	0.55	0.85	0.77	0.70	0.61	0.55	0.87	0.78	0.71	0.62	0.55	0.87	0.79	0.71	0.62	0.55
6	0.82	0.74	0.68	0.59	0.53	0.83	0.75	0.68	0.60	0.53	0.84	0.76	0.69	0.60	0.53	0.85	0.76	0.69	0.60	0.53
8	0.79	0.71	0.65	0.57	0.51	0.80	0.72	0.65	0.57	0.51	0.81	0.72	0.65	0.57	0.51	0.81	0.73	0.66	0.57	0.51
10	0.77	0.69	0.63	0.55	0.49	0.78	0.70	0.63	0.55	0.49	0.79	0.70	0.63	0.55	0.49	0.79	0.71	0.64	0.55	0.49

Table 3.11 Rating factor F2 (installed in ground) for PVC insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	0.9	0.91	0.93	0.96	0.91	0.98	0.99	1	0.96	0.91	1.05	1.04	1.03	0.97	0.91	1.14	1.09	1.04	0.97	0.91
2	0.85	0.85	0.85	0.81	0.76	0.93	0.92	0.89	0.82	0.76	0.98	0.95	0.9	0.82	0.76	1.03	0.96	0.9	0.82	0.76
3	0.8	0.79	0.78	0.72	0.66	0.87	0.86	0.8	0.72	0.66	0.93	0.86	0.8	0.73	0.66	0.95	0.87	0.81	0.73	0.66
4	0.77	0.77	0.74	0.67	0.61	0.85	0.81	0.75	0.67	0.61	0.89	0.82	0.75	0.68	0.61	0.9	0.82	0.76	0.68	0.61
5	0.75	0.75	0.7	0.63	0.57	0.84	0.77	0.71	0.63	0.57	0.85	0.77	0.71	0.63	0.57	0.86	0.78	0.72	0.64	0.57
6	0.74	0.73	0.67	0.6	0.55	0.81	0.74	0.68	0.6	0.55	0.82	0.74	0.68	0.61	0.55	0.83	0.75	0.69	0.61	0.55
8	0.73	0.69	0.63	0.56	0.51	0.77	0.7	0.64	0.56	0.51	0.77	0.7	0.64	0.57	0.51	0.78	0.71	0.64	0.57	0.51
10	0.71	0.66	0.6	0.53	0.48	0.74	0.67	0.61	0.54	0.48	0.74	0.67	0.61	0.54	0.48	0.75	0.67	0.61	0.54	0.48

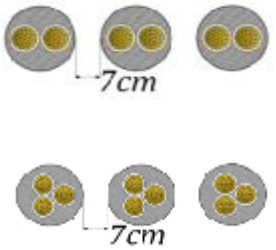


Table 3.12 Rating factor F2 (installed in ground) for XLPE insulation

No. Of Systems	Soil thermal resistivity																			
	0.7					1					1.5					2.50				
	Load factor					Load factor					Load factor					Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.09	1.04	0.99	0.93	0.87	1.11	1.05	1.00	0.93	0.87	1.13	1.07	1.01	0.94	0.87	1.17	1.09	1.03	0.94	0.87
2	0.97	0.90	0.84	0.77	0.71	0.98	0.91	0.85	0.77	0.71	1.00	0.92	0.86	0.77	0.71	1.02	0.94	0.87	0.78	0.71
3	0.88	0.80	0.74	0.67	0.61	0.89	0.82	0.75	0.67	0.61	0.90	0.82	0.76	0.68	0.61	0.92	0.83	0.76	0.68	0.61
4	0.83	0.75	0.69	0.62	0.56	0.84	0.76	0.70	0.62	0.56	0.85	0.77	0.70	0.62	0.56	0.82	0.78	0.71	0.63	0.56
5	0.79	0.71	0.65	0.58	0.52	0.80	0.72	0.66	0.58	0.52	0.80	0.73	0.66	0.58	0.52	0.81	0.73	0.67	0.59	0.52
6	0.76	0.68	0.62	0.55	0.50	0.77	0.69	0.63	0.55	0.50	0.77	0.70	0.63	0.56	0.50	0.78	0.70	0.64	0.56	0.50
8	0.72	0.64	0.58	0.51	0.46	0.72	0.65	0.59	0.52	0.46	0.73	0.65	0.59	0.52	0.46	0.74	0.66	0.59	0.52	0.46
10	0.69	0.61	0.56	0.49	0.44	0.69	0.62	0.56	0.49	0.44	0.70	0.62	0.56	0.49	0.44	0.70	0.63	0.57	0.49	0.44

Table 3.13 Rating factor F2 (installed in ground) for XLPE insulation

No. Of Systems	Soil thermal resistivity																			
	0.7					1					1.5					2.50				
	Load factor					Load factor					Load factor					Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.09	1.04	0.99	0.93	0.87	1.11	1.05	1.00	0.93	0.87	1.13	1.07	1.01	0.94	0.87	1.17	1.09	1.03	0.94	0.87
2	1.01	0.94	0.89	0.82	0.75	1.02	0.95	0.89	0.82	0.75	1.04	0.97	0.90	0.82	0.75	1.06	0.98	0.91	0.83	0.75
3	0.94	0.87	0.81	0.74	0.67	0.95	0.88	0.82	0.74	0.67	0.97	0.89	0.82	0.74	0.67	0.99	0.90	0.83	0.74	0.67
4	0.91	0.84	0.78	0.70	0.64	0.92	0.84	0.78	0.70	0.64	0.93	0.85	0.79	0.70	0.64	0.95	0.86	0.79	0.71	0.64
5	0.88	0.80	0.74	0.67	0.60	0.89	0.81	0.75	0.67	0.60	0.90	0.82	0.75	0.67	0.60	0.91	0.83	0.76	0.67	0.60
6	0.86	0.79	0.72	0.65	0.59	0.87	0.79	0.73	0.65	0.59	0.88	0.80	0.73	0.65	0.59	0.89	0.81	0.74	0.65	0.59
8	0.83	0.76	0.70	0.62	0.56	0.84	0.76	0.70	0.62	0.56	0.85	0.77	0.70	0.62	0.56	0.86	0.78	0.71	0.62	0.56
10	0.81	0.74	0.68	0.60	0.54	0.82	0.74	0.68	0.60	0.54	0.83	0.75	0.68	0.61	0.54	0.84	0.76	0.69	0.61	0.54

Table 3.14 Rating factor F2 (installed in ground) for XLPE insulation

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.08	1.05	0.99	0.91	0.85	1.13	1.07	1	0.92	0.85	1.18	1.09	1.01	0.92	0.85	1.19	1.11	1.03	0.93	0.85
2	1.01	0.93	0.86	0.77	0.71	1.03	0.94	0.87	0.78	0.71	1.05	0.95	0.88	0.78	0.71	1.06	0.96	0.88	0.79	0.71
3	0.92	0.84	0.77	0.69	0.62	0.93	0.85	0.77	0.69	0.62	0.95	0.86	0.78	0.69	0.62	0.96	0.86	0.79	0.69	0.62
4	0.88	0.8	0.73	0.65	0.58	0.89	0.8	0.73	0.65	0.58	0.9	0.81	0.74	0.65	0.58	0.91	0.82	0.74	0.65	0.58
5	0.84	0.76	0.69	0.61	0.55	0.85	0.77	0.7	0.61	0.55	0.87	0.78	0.7	0.62	0.55	0.87	0.78	0.71	0.62	0.55
6	0.82	0.74	0.67	0.59	0.53	0.83	0.75	0.68	0.6	0.53	0.84	0.75	0.68	0.6	0.53	0.85	0.76	0.69	0.6	0.53
8	0.79	0.71	0.64	0.57	0.51	0.8	0.71	0.65	0.57	0.51	0.81	0.72	0.65	0.57	0.51	0.81	0.72	0.65	0.57	0.51
10	0.77	0.69	0.62	0.55	0.49	0.78	0.69	0.63	0.55	0.49	0.78	0.7	0.63	0.55	0.49	0.79	0.7	0.63	0.55	0.49

Table 3.15 Rating factor F2 (installed in ground) for XLPE insulation (and single-core D.C)

No. Of Systems	Soil thermal resistivity																			
	0.7 Load factor					1 Load factor					1.5 Load factor					2.50 Load factor				
	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00	0.50	0.60	0.70	0.85	1.00
1	1.02	1.03	0.99	0.94	0.89	1.06	1.05	1	0.94	0.89	1.09	1.06	1.01	0.94	0.89	1.11	1.07	1.02	0.95	0.89
2	0.95	0.89	0.84	0.77	0.72	0.98	0.91	0.85	0.78	0.72	0.99	0.92	0.86	0.78	0.72	1.01	0.94	0.87	0.79	0.72
3	0.86	0.8	0.74	0.68	0.62	0.89	0.81	0.75	0.68	0.62	0.9	0.83	0.77	0.69	0.62	0.92	0.84	0.77	0.69	0.62
4	0.82	0.75	0.69	0.63	0.57	0.84	0.76	0.7	0.63	0.57	0.85	0.78	0.71	0.63	0.57	0.86	0.78	0.72	0.64	0.57
5	0.78	0.71	0.65	0.59	0.53	0.8	0.72	0.66	0.59	0.53	0.81	0.73	0.67	0.59	0.53	0.82	0.74	0.67	0.6	0.53
6	0.75	0.68	0.63	0.56	0.51	0.77	0.69	0.63	0.56	0.51	0.78	0.7	0.64	0.57	0.51	0.79	0.71	0.65	0.57	0.51
8	0.71	0.64	0.59	0.52	0.47	0.72	0.65	0.59	0.52	0.47	0.73	0.66	0.6	0.52	0.47	0.74	0.66	0.6	0.53	0.47
10	0.68	0.61	0.56	0.49	0.44	0.69	0.62	0.56	0.5	0.44	0.7	0.63	0.57	0.5	0.44	0.71	0.63	0.57	0.5	0.44

4. Voltage drop

Length and current are to be multiplied by the tabulated values of voltage drop in this section, to calculate the voltage drop in mV.

The values of voltage drop are given for a current of one ampere for 1 meter run, and represent the result of the voltage drops in all the circuit conductors.

The values of voltage drop in Table 4.1, 4.2 and 4.3, assume that the conductors are at their maximum permitted normal operating temperature.

The values of voltage drop in Table 4.1, 4.2 and 4.3, for cables having conductors of 16 mm^2 or less cross-sectional area are calculated based on resistance only and given as (mV/A/m)r. For cables having conductors greater than 16 mm^2 cross-sectional area calculations of voltage drop were based on impedance value and given as (mV/A/m)z, as per IEE wiring regulations.

$$V_d = V_{/A/m} \times L \times I \qquad (4.1)$$

Vd: Voltage drop in (mV)
V/A/m: Tabulated voltage drop in mV/A/m (table 4.1, table 4.2 or table 4.3), for 3-phase circuit the tabulated voltage drop relates to line voltage
L: Length-run in meter (m)
I: The designed current of the circuit in ampere (A)

Table 4.1 Voltage drop (mV/A/m) for Copper/PVC cables

SIZE mm^2	A.C								D.C	
	Un-armored			Armored			Un-armored /Armored		Un-armored /Armored	
	Single-core			Single-core			Muli-core		Sinlge-core	Multi-core
	3/4 cables Touching Trefoil	3/4 cables Touching Flat	3/4 cables Flat*	3/4 cables Touching Trefoil	3/4 cables Touching Flat	3/4 cables Flat*	Two-core 1φ (A.C)	3/4-core 3φ (A.C)	Two cables	Two-core
1		38		-	-	-	44	38	44	
1.5		25		-	-	-	29	25	29	
2.5		15		-	-	-	18	15	18	
4		9.5		-	-	-	11	9.5	11	
6		6.4		-	-	-	7.3	6.4	7.3	
10		3.8		-	-	-	4.4	3.8	4.4	
16		2.4		-	-	-	2.8	2.4	2.8	
25	1.5	1.55	1.55	-	-	-	1.75	1.5	1.75	
35	1.1	1.1	1.15	-	-	-	1.25	1.1	1.25	
50	0.82	0.84	0.86	0.82	0.84	0.86	0.94	0.81	0.93	
70	0.57	0.6	0.63	0.58	0.62	0.68	0.65	0.57	0.63	
95	0.43	0.47	0.51	0.45	0.5	0.57	0.5	0.43	0.46	
120	0.36	0.4	0.44	0.37	0.43	0.5	0.41	0.35	0.36	
150	0.3	0.34	0.4	0.32	0.38	0.45	0.34	0.29	0.29	
185	0.26	0.31	0.36	0.27	0.34	0.41	0.29	0.25	0.23	
240	0.22	0.27	0.34	0.23	0.3	0.37	0.24	0.21	0.18	
300	0.19	0.25	0.32	0.21	0.28	0.34	0.21	0.185	0.145	
400	0.175	0.24	0.31	0.195	0.26	0.32	0.185	0.16	0.105	
500	0.16	0.23	0.3	0.18	0.25	0.3	-	-	0.086	
630	0.15	0.22	0.29	0.17	0.23	0.28	-	-	0.068	

* Spacings between cables ≤ Cable diameter

Table 4.2 Voltage drop (mV/A/m) for Copper/XLPE cables

	A.C								D.C	
	Un-armored			Armored			Un-amored/Armored		Un-amored/Armored	
	Single-core			Single-core			Muli-core		Sinlge-core	Multi-core
SIZE mm^2	3/4 cables Touching Trefoil	3/4 cables Touching Flat	3/4 cables Flat*	3/4 cables Touching Trefoil	3/4 cables Touching Flat	3/4 cables Flat*	Two-core 1φ (A.C)	3/4-core 3φ (A.C)	Two cables	Two-core
1		40		-	-	-	46	40	46	
1.5		27		-	-	-	31	27	31	
2.5		16		-	-	-	19	16	19	
4		10		-	-	-	12	10	12	
6		6.8		-	-	-	7.9	6.8	7.9	
10		4		-	-	-	4.7	4	4.7	
16		2.5		-	-	-	2.9	2.5	2.9	
25	1.6	1.6	1.65	-	-	-	1.9	1.65	1.85	
35	1.15	1.15	1.2	-	-	-	1.35	1.15	1.35	
50	0.87	0.87	0.89	0.87	0.88	0.9	1	0.87	0.99	
70	0.61	0.62	0.65	0.62	0.65	0.7	0.69	0.6	0.68	
95	0.45	0.46	0.49	0.47	0.52	0.58	0.52	0.45	0.49	
120	0.37	0.38	0.42	0.39	0.44	0.51	0.42	0.37	0.39	
150	0.31	0.32	0.37	0.33	0.39	0.45	0.35	0.3	0.32	
185	0.26	0.28	0.33	0.28	0.34	0.41	0.29	0.26	0.25	
240	0.22	0.24	0.29	0.24	0.3	0.37	0.24	0.21	0.195	
300	0.195	0.21	0.27	0.21	0.28	0.34	0.21	0.185	0.155	
400	0.175	0.195	0.26	0.195	0.27	0.33	0.19	0.165	0.12	
500	0.16	0.18	0.25	0.18	0.25	0.31	-	-	0.093	
630	0.15	0.17	0.24	0.17	0.24	0.29	-	-	0.073	

* Spacings between cables ≤ Cable diameter

Table 4.3 Voltage drop (mV/A/m) for Aluminum/XLPE cables

SIZE mm^2	A.C								D.C	
	Un-armored			Armored			Un-armored/Armored		Un-amored/Armored	
	Single-core			Single-core			Muli-core		Sinlge-core	Multi-core
	3/4 cables	3/4 cables	3/4 cables	3/4 cables	3/4 cables	3/4 cables	Two-core 1φ	3/4 core 3φ	Two cables	Two-core
16	-	-	-	-	-	-	4.8	4.2	-	4.8
25	-	-	-	-	-	-	3.1	2.7	-	3.1
35	-	-	-	-	-	-	2.2	1.95	-	2.2
50	1.45	1.46	1.48	1.4	1.4	1.4	1.65	1.45	1.65	
70	0.98	1	1.02	0.98	1	1.05	1.15	0.97	1.13	
95	0.73	0.75	0.78	0.74	0.78	0.83	0.84	0.72	0.82	
120	0.59	0.61	0.64	0.6	0.64	0.7	-	0.58	0.66	
150	0.47	0.5	0.54	0.49	0.54	0.6	-	0.47	0.53	
185	0.39	0.43	0.47	0.41	0.47	0.53	-	0.39	0.42	
240	0.32	0.35	0.41	0.34	0.39	0.46	-	0.31	0.32	
300	0.27	0.31	0.37	0.29	0.34	0.41	-	0.26	0.26	

* Spacings between cables ≤ Cable diameter

5. Impedance

Maximum permissible values for resistance per unit length on D.C. at 20°C are given in Table 5.1 and Table 5.2. The D.C. resistance at operation temperature T °C, is calculated using the below equation,

$$R_T = R_{20}\,[1 + \alpha_{20}\,(T - 20)] \qquad (7.1)$$

R_T: Resistance at operation temperature
R_{20}: Resistance at 20 oC
T: Operating temperature in oC
α_{20}: Resistance temperature coefficient (See table B, properties of metals used in cables)

The values of A.C. Resistance at maximum permissible temperature, Reactance at 50Hz and Impedance are given in Table 5.1 and Table 5.2, for Copper and Aluminum conductors with PVC and XLPE insulation.

Table 5.1 Resistance, Reactance and Impedance values Ω/Km

Copper conductor

Single & Multi Core				PVC (70 ℃)				XLPE (90 ℃)			
				Single Core Cables		Multi Core Cables		Single Core Cables		Multi Core Cables	
Size mm2	R(DC) 20 ℃	R(AC) PVC 70 ℃ (Trefoil)	R(AC) XLPE 90 ℃ (Trefoil)	X Reactance (50Hz)	Z Impedance	X Reactance (50Hz)	Z Impedance	X Reactance (50Hz)	Z Impedance	X Reactance (50Hz)	Z Impedance
1.5	12.10	14.5	15.4	0.138	14.478	0.138	14.478	0.138	15.429	0.138	15.429
2.5	7.41	8.87	9.45	0.124	8.867	0.119	8.867	0.124	9.449	0.119	9.449
4	4.61	5.52	5.88	0.119	5.517	0.110	5.517	0.119	5.879	0.110	5.879
6	3.08	3.69	3.93	0.112	3.687	0.101	3.687	0.112	3.929	0.101	3.929
10	1.83	2.19	2.33	0.110	2.192	0.091	2.191	0.110	2.336	0.091	2.335
16	1.15	1.38	1.47	0.103	1.380	0.088	1.379	0.103	1.470	0.088	1.469
25	0.727	0.870	0.923	0.101	0.876	0.086	0.874	0.101	0.932	0.086	0.931
35	0.524	0.627	0.668	0.096	0.634	0.082	0.632	0.096	0.675	0.082	0.673
50	0.387	0.463	0.494	0.093	0.473	0.082	0.471	0.093	0.502	0.082	0.500
70	0.268	0.321	0.342	0.088	0.333	0.079	0.331	0.088	0.353	0.079	0.351
95	0.193	0.232	0.247	0.086	0.248	0.078	0.246	0.086	0.262	0.078	0.259
120	0.153	0.184	0.196	0.083	0.203	0.076	0.200	0.083	0.213	0.076	0.210
150	0.124	0.150	0.160	0.083	0.172	0.076	0.168	0.083	0.179	0.076	0.176
185	0.0991	0.121	0.128	0.083	0.147	0.076	0.143	0.083	0.153	0.076	0.149
240	0.0754	0.093	0.099	0.081	0.124	0.075	0.120	0.081	0.127	0.075	0.123
300	0.0601	0.0754	0.0802	0.080	0.111	0.075	0.107	0.080	0.112	0.075	0.108
400	0.0470	0.0607	0.0617	0.078	0.098	0.074	0.095	0.078	0.099	0.074	0.096
500	0.0366	0.0495	0.0491	0.077	0.091	0.073	0.088	0.077	0.091	0.073	0.088
630	0.0283	0.0372	0.0393	0.076	0.085	0.073	0.082	0.076	0.086	0.073	0.083

Table 5.2 Resistance, Reactance and Impedance values Ω/Km,

Aluminum conductor

Single & Multi Core			XLPE (90 ℃)			
			Single Core Cables		Multi Core Cables	
Size mm2	R(DC) 20 ℃	R(AC) XLPE 90 ℃	X Reactance (50Hz)	Z Impedance	X Reactance (50Hz)	Z Impedance
16	1.910	2.449	0.103	2.452	0.088	2.451
25	1.200	1.540	0.101	1.541	0.086	1.541
35	0.868	1.120	0.096	1.117	0.082	1.116
50	0.641	0.822	0.093	0.827	0.082	0.825
70	0.443	0.568	0.088	0.574	0.079	0.572
95	0.320	0.411	0.086	0.419	0.078	0.417
120	0.253	0.325	0.083	0.334	0.076	0.332
150	0.206	0.265	0.083	0.276	0.076	0.274
185	0.164	0.212	0.083	0.226	0.076	0.223
240	0.125	0.162	0.081	0.179	0.075	0.177
300	0.100	0.129	0.080	0.152	0.075	0.149
400	0.0778	0.101	0.078	0.128	0.074	0.125
500	0.0605	0.080	0.077	0.111	0.073	0.108
630	0.0468	0.063	0.076	0.099	0.073	0.096

6. Short circuit rating of cables

Mainly, short circuit current causes effects which are proportional to the square of the current, a temperature rise in the conductor components subject to current flow such as conductor and armor. Indirectly the temperature of adjoining insulation and protective covers also increases. Electromagnetic forces between the current carrying components.

The short circuit currents at permissible short circuit temperature are given in table-6.1 for copper and aluminum conductors. Temperature at the commencement of a short circuit was taken the maximum permissible conductor temperature.

Table 6.1 Short circuit rating of cables in KA for 1s

	PVC (70 °C)		XLPE (90 °C)	
Size mm^2	Copper	Aluminum	Copper	Aluminum
1.5	0.173	0.114	0.215	0.141
2.5	0.288	0.190	0.358	0.235
4	0.460	0.304	0.572	0.376
6	0.690	0.456	0.858	0.564
10	1.150	0.760	1.430	0.940
16	1.840	1.216	2.288	1.504
25	2.88	1.90	3.58	2.35
35	4.03	2.66	5.01	3.29
50	5.75	3.80	7.15	4.70
70	8.05	5.32	10.01	6.58
95	10.93	7.22	13.59	8.93
120	13.80	9.12	17.16	11.28
150	17.25	11.40	21.45	14.10
185	21.28	14.06	26.46	17.39
240	27.60	18.24	34.32	22.56
300	34.50	22.80	42.90	28.20
400	41.20	27.20	57.20	37.60
500	51.50	34.00	71.50	47.00
630	64.89	42.84	90.09	59.22

7. Guidelines for cable laying

7.1 Minimum permissible bending radii r when laying cable

Multi-core cables	12 X D
Single-core cables	15 X D

D: outer diameter of cable

Where a bend is to be made once only as for example immediately before a sealing end then providing proper procedures are carried out (heating to 30 °C and bending over a form tool), the value of r can be reduced to 50% of those above.

7.2 Maximum permissible tensile strength for cables

Ø For cables pulled with Stocking

PVC and XLPE insulated armored power cables

$$P = 9\,D^2 \qquad (8.1)$$

PVC and XLPE insulated unarmored power cables

$$P = 5\,D^2 \qquad (8.2)$$

P: Pulling force in Newton
D: Outer diameter of cables in mm

Ø For cables pulled by pulling eye (Pulling head)

If the cables are pulled by gripping the conductor directly with pulling eye (head), the maximum permissible tensile stress depends on the material of the conductor and on their cross section as given below:

For Aluminum conductors $30\ N/mm^2$

For copper conductors $50\ N/mm^2$