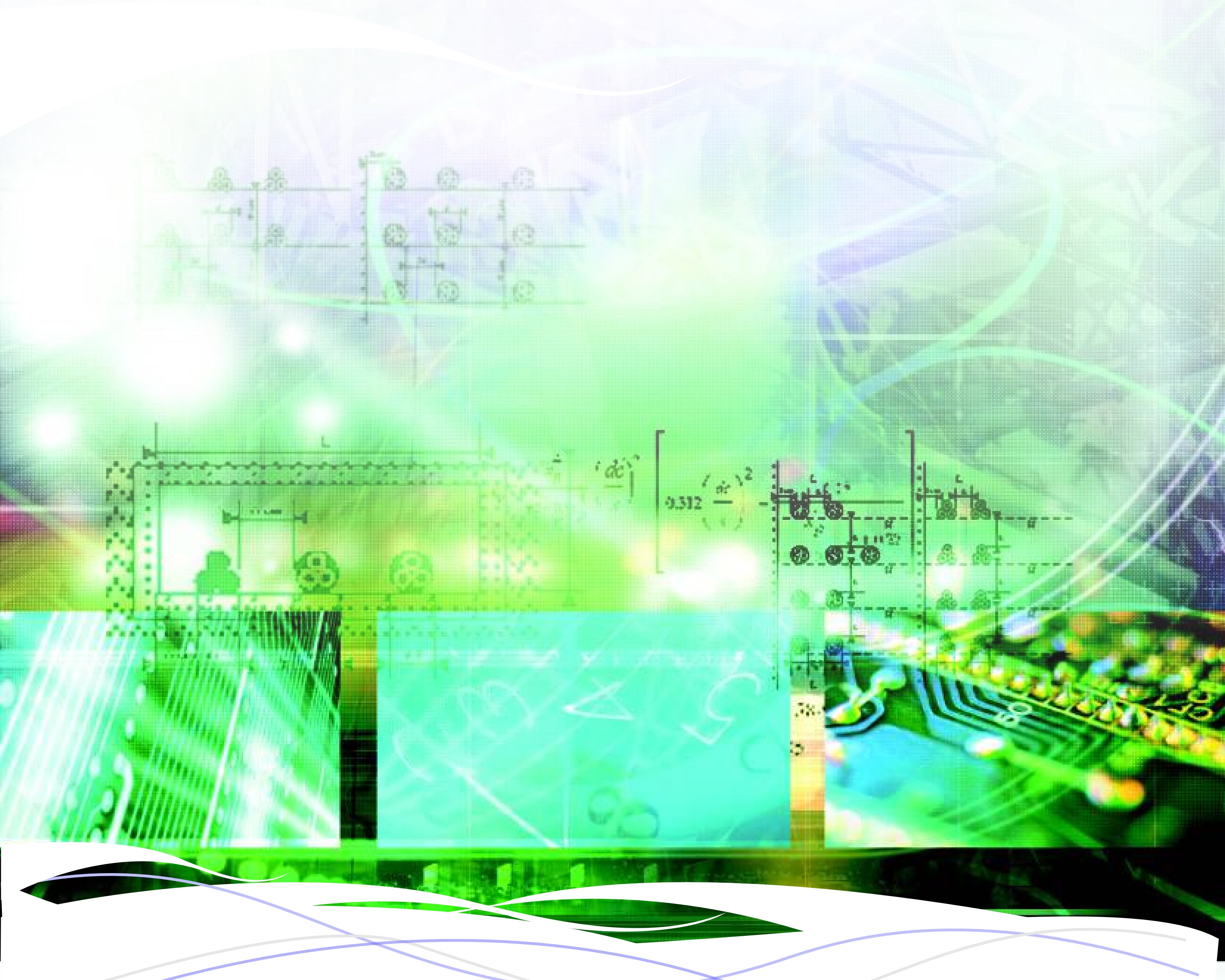


SUMMARY

Transmission cables practices are fairly similar in many countries. For wiring type cables, many individual countries have preferences for particular designs or materials, but the difference is not fundamental. The present catalog covers essentially low and medium voltage cables up to 33 KV, manufactured according to European and international specifications which are largely used in Europe and the majority of countries throughout the world .

Power cables are distinguished in the following categories

Overhead (Aerial) lines with bare conductors.

Overhead (Aerial) lines with insulated conductors.

Low voltage (LV) power cables for indoor installations.

Low voltage (LV) power cables for outdoor installations.

Low voltage (LV) special cables destined to special uses.

Medium Voltage (MV) power cables.

OVERHEAD POWER LINES

Overhead lines are generally divided from the point of view of their use, into 3 main categories , as follows :

- Overhead lines for low voltage power distribution in rural areas, as well as in small villages
- Overhead lines used for medium voltage power transportation and distribution
- Overhead lines used for High Voltage power transportation from generating stations to big power consumers

Aerial lines with bare conductors

- Bare soft drawn stranded copper conductors
- Bare hard drawn stranded copper conductors.
- Bare hard drawn stranded all aluminium conductors (AAC).
- Bare hard drawn stranded all aliminium alloy conductors (AAAC).
- Aluminium conductors steel reinforced (ACSR).

Aerial lines with insulated conductors

- Weather proof service drop copper cables 0,6/1KV , XLPE insulated for over head power lines.
- Weather proof service drop aluminium cables 0,6/1KV, XLPE insulated for over head power lines.

LOW VOLTAGE INDOOR CABLES

Indoor cables are destined for permanent (fixed) as well as for movable installations inside covered areas, protected from direct rain falls, as well as from moisture presence. These cables are mainly composed of solid or stranded or flexible copper conductors, insulated with PVC Wherever fire retardant qualities, reduced fumes, toxic and corrosive gases emission in case of fire are required, they should be insulated and sheathed with LSZH* material. The most common types of indoor cables, used in internal fixed or movable installations are the following:

- Single core cables with solid or stranded copper conductors, PVC insulated.
- Single core cables with flexible copper conductors, PVC insulated.
- Multicore cables , with solid or stranded copper conductors, PVC insulated and PVC sheathed.
- Multicore cables, with flexible copper conductors, PVC insulated and PVC sheathed.
- Flt-twin or flat-three core cables, with solid or stranded copper conductors, PC insulated and PVC sheathed.
- Multicore cables , with solid or stranded copper conductors, LSZH* insulated and LSZH* sheathed.

*LSZH : Low Smoke Zero Halogen material

LOW VOLTAGE OUTDOOR CABLES

Outdoor low voltage cables are usually exposed to serious weather influences, high mechanical stresses and dangerous chemical attacks,

For these reasons, they are characterized by increased thickness in the insulation and in the protecting outer sheath, as well as by special insulating and sheathing in case of presence of various dangerous chemicals in the ground, where the cables are to be placed and whenever fire retardant qualities are required in case of fire.

When the cables are destined to be buried direct in ground, they are normally protected with steel tape, when limited tensile stress are present during installation and only protection against mechanical damages are requested.

When the contrary, cables subjected to higher tensile stress during their installation, due to high pulling forces or to the presence of not stable or sandy ground, as well as when exposed to exaggerate mechanical pressures, they must be provided with an armour of round or flat galvanized steel wires

The most common types of outdoor cables, used in external permanent (fixed) installations, are the following:

- Single core and multicore cables with solid or stranded copper or aluminium conductors , PVC insulated and PVC sheathed.
- Multicore cables with solid or stranded copper or aluminium conductors , PVC or XLPE insulated and PVC sheathed.
- Multicore cables with solid or stranded copper conductors, PVC or XLPE insulated, steel tape or steel wires armoured and PVC sheathed.
- Multicore cables with stranded sector-shape copper or aluminium conductors, PVC or XLPE insulated and

PVC sheathed.

- Multicore cables with stranded sector-shape copper or aluminium conductors, PVC or XLPE insulated, Steel tape or steel wire armoured and PVC sheathed.

- Multicore cables with solid or stranded copper conductors, PVC or XLPE insulated, steel tape or steel wires armoured and PVC sheathed

- Multicore cables with solid or stranded copper or aluminium conductors, LSZH* insulated and LSZH* sheathed.

*LSZH : Low Smoke Zero Halogen material

CONTROL CABLES FOR INDOOR AND OUTDOOR INSTALLATIONS

Control cables are composed of soft drawn solid, stranded, flexible and super flexible copper conductors, PVC or XLPE insulated, assembled into a cable core, filled with plastic or rubber materials, eventually screened with copper tapes or wires, double steel tape or steel wire armoured and finally PVC sheathed.

Wherever fire retardant qualities, reduced fumes, toxic and corrosive gases emission in case of fire are required, they should be insulated and sheathed with HFFR* material.

Control cable can be used either for indoor installations as well for outdoor installations.

The distinction of the insulated conductors is mainly realized by numbering the insulation with white numbers printed on black insulation. The induction of any undesirable signal, can be decreased or totally avoided, by applying special screening material, such as coppertapes or wires application, helped by special armour etc., in order to reduce the level of the disturbing signals so much, as to minimize the risk of the primary signal alteration.

*HFFR : Halogen free flame retardant

SPECIAL CABLES

There is a very big variety of special cables, appropriately manufactured to make front to special requests like welding, airport lighting and ship wiring.

COXIAL AND TV ANTENNA SATELLITE CABLE

Coaxial cables are commonly used for central installations in civil buildings, where a central antenna positioned on the highest point of the building, is connected to all apartments TV receivers, through vertical distributing lines of coaxial cables, which feeds the TV plugs.

MEDIUM VOLTAGE CABLES

Medium voltage (MV) cables are normally used for transporting electric power at medium distances and for safety reasons; they are installed underground directly to the soil or into ducts or in air over steel racks anchored against the wall. The MV cables covered by IEC 60502 are ranging from 3KV up to 33 KV.

1- CONDUCTORS (usually copper, aluminium , aluminium alloy)

2- INSULATION (usually PVC, PE, XLPE , RUBBER, LSZH).

3- SHEATH (usually PVC, RUBBER, HFFR)

4- ARMOUR (usually steel tapes, steel round or flat wires, aluminium tapes and wires).

5- OUTER PROTECTION OF CABLES (protection against chemicals, as well as against heat , flame, rodents, termites etc.).

CONDUCTORS

Cable conductors are designed to conform to a certain range of nominal areas in graduated steps according to IEC 60228. The value of ohmic resistance at 20° C of each area, is also given by IEC 60228.

Conductors are distinguished into following classes:

Class1 : Solid copper and aluminum conductors

Class 2 : Stranded copper and aluminium conductors

Class 5 : Stranded flexible copper conductors

Class 6 : Stranded super flexible copper conductors

INSULATION AND SHEATHING MATERIAL

The insulating materials used in power cables are essentially the following : Thermoplastic materials (PVC and PE) Thermosetting materials (XLPE) Electrometric materials as :

Natural rubber

Synthetic rubber

Special insulating and sheathing materials (EPR or EPDM, EVA, PCP, CSPE and CPE).

CABLE ARMOUR

All underground cables especially those laid direct to ground are armoured with steel tapes or wires in order to protect them against mechanical stressed and damages.

Standard specifications caters for a wide range of choice for armour :

- Plain or galvanized steel tape
- Plain or galvanized flat steel wires
- Galvanized round steel wires
- Aluminium flat wires or strips

The final choice of the type of armour depends on the specifications.

Galvanized steel tapes are preferred by users where the cables are supposed to be laid in aggressive environments Where the armour is also used as an earth conductor, steel wire armour is preferred.

Steel round or flat wires are usually

applied as an armour in all cases, in which the cables are subjected to higher mechanical stresses, especially longitudinal tensile stress during cable laying or in case of sandy soils and soils with very weak compaction.

Single-core cables for AC and three-phase operation system, are not armoured as a rule, in order to avoid excessive additional losses. However in the cases where the armour is necessary, an armour of non-magnetic material (copper or aluminium) has to be provided.

OUTER PROTECTION OF CABLE

Metal sheathed cables , as well as armoured power cables must be protected against corrosion, only cables having an outer sheath of PVC do not practically need any protection against corrosion, as this sheath is by itself corrosion resistant against nearly all chemicals eventually present in the soil.

Protection against rodents and termites

There are additives to the sheathing material which by their repellent or rat-killing properties repel or kill termites or rodents, especially rats.

Protection again Hydrocarbons

The cable used in oil and petrochemical units is subject to various chemical products and hydrocarbons.
It is thus particularly important to protect them against the attacks of the following hydrocarbons groups :

- Aliphatic hydrocarbons
- Aromatic hydrocarbons

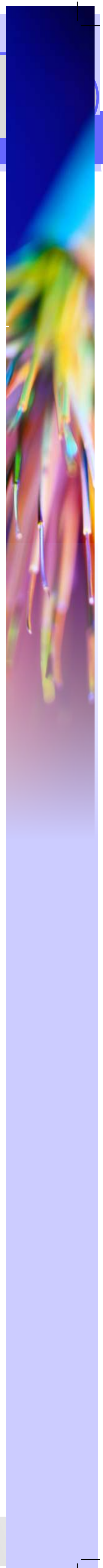
To resist to the aliphatic hydrocarbons, cables are protected by PVC nitrate sheath.

Protection against fire

Particularly in public and industrial setting, when fire retardant qualities are required in case of fire, filling and sheathing materials should be flame or fire retardant. Moreover, the educed fumes, toxic and gases remissions of HFFR filling and sheathing materials in case of fire, achieve to the cable the propriety that to be used in areas when strict safety standards have to be respected

Water proof cables

To secure longitudinal water tightness throughout the cable length, a suitable swelling tape is helically applied under the sheath. This tape is made up of a matter that swells-up moisture and stop water tightness.



Solid copper and aluminum conductors Class 1

TYPE	Approximate diameter (mm)		Maximum electrical resistance at 20° C	
	Copper mm	Aluminium mm	copper	Aluminum
1,5	1,38	-	12,10	-
2,5	1,78	-	7,41	-
4	2,25	-	4,61	-
6	2,76	-	3,08	-
10	3,57	3,55	1,83	3,08
16	4,50	4,50	1,15	1,91
25	5,65	5,55	0,727	1,20
35	6,60	6,45	0,524	0,868
50	7,70	7,60	0,387	0,641
70	9,30	9,10	0,268	0,443
95	10,90	10,70	0,193	0,320
120	12,30	12,00	0,153	0,253
150	13,60	13,30	0,124	0,206
185	-	15,00	-	0,164
240	-	17,10	-	0,125
300	-	19,10	-	0,100

Stranded conductors class 2

TYPE	Stranded circular copper and aluminium conductors		Stranded compacted copper and aluminium conductors						Maximum electrial resistance at 20° C (Ω /km)	
	Minimum number of wires	Approximate conductor diameter mm	Minimum number of wires				Approximate conductor diameter mm		copper	Aluminium
			circular shape		Sector shape					
			copper	Alu	copper	Alu	copper	Alu		
1,5	7	1,5	-	-	-	-	1,70	-	12,10	-
2,5	7	2,1	-	-	-	-	2,10	-	7,41	-
4	7	2,5	-	-	-	-	2,55	-	4,61	-
6	7	3,1	-	-	-	-	2,90	-	3,08	-
10	7	4,05	-	-	-	-	3,80	-	1,83	3,08
16	7	5,1	6	6	-	-	4,80	4,65	1,15	1,91
25	7	6,4	6	6	6	6	6,00	5,90	0,727	1,20
35	7	7,6	6	6	6	6	7,10	6,80	0,524	0,868
50	19	8,9	6	6	6	6	8,40	7,90	0,387	0,641
70	19	10,7	12	12	12	12	10,00	9,75	0,268	0,443
95	19	12,6	15	15	15	15	11,20	11,40	0,193	0,320
120	37	14,2	18	15	18	15	12,90	12,60	0,153	0,253
150	37	15,7	18	15	18	15	14,20	14,10	0,124	0,206
185	37	17,6	30	30	30	30	16	15,60	0,0991	0,164
240	61	20,2	34	30	34	30	18,30	17,90	0,0754	0,125
300	61	22,7	34	30	34	30	20,20	20,10	0,0601	0,100
400	61	25,6	53	53	53	53	-	23,20	0,0470	0,0778
500	61	28,8	53	53	53	53	26,60	27,40	0,0366	0,0605
630	91	32,8	53	53	53	53	32,40	29,60	0,0283	0,0469
800	91	37,0	53	53	-	-	36,30	36,30	0,0221	0,0367
1000	91	41,6	53	53	-	-	-	-	0,0176	0,0291

Stranded and flexible conductors class 5

TYPE	Maximum diameter of wire mm	Approximate diameter of conductor mm	Maximum electrical resistance at 20° C (Ω /km)	
			copper	Tinned copper
0.5	0.21	0.9	39	40.1
0.75	0.21	1.1	26	26.7
1	0.21	1.3	19.5	20
1.5	0.26	1.5	13.3	13.7
2.5	0.26	1.8	7.98	8.21
4	0.31	2.4	4.95	5.09
6	0.31	3.0	3.30	3.39
10	0.41	4.0	1.91	1.95
16	0.41	5.1	1.21	1.24
25	0.41	6.6	0.780	0.795
35	0.41	7.8	0.554	0.565
50	0.41	9.3	0.386	0.393
70	0.51	11.5	0.272	0.277
95	0.51	13.1	0.206	0.210
120	0.51	14.7	0.161	0.164
150	0.51	16.7	0.129	0.132
185	0.51	18.6	0.106	0.108
240	0.51	21.0	0.0801	0.0817
300	0.51	23.6	0.0641	0.0654
400	0.51	27.5	0.0486	0.0495
500	0.61	31.3	0.0384	0.0391

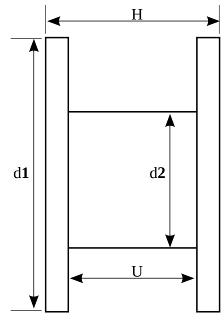
Stranded and super flexible conductors class 6

TYPE	Maximum diameter of wire mm	Approximate diameter of conductormm	Maximum electrical resistance at 20° C (Ω /km)	
			Plain copper	Tinned copper
0,5	0,16	0,9	39	40,1
0,75	0,16	1,1	26	26,7
1	0,16	1,3	19,5	20
1,5	0,16	1,6	13,3	13,7
2,5	0,16	2,3	7,98	8,21
4	0,16	2,9	4,95	5,09
6	0,21	3,4	3,30	3,39
10	0,21	4,5	1,91	1,95
16	0,21	5,1	1,21	1,24
25	0,21	6,6	0,780	0,795
35	0,21	8,6	0,554	0,565
50	0,31	10,2	0,386	0,393
70	0,31	12,3	0,272	0,277
95	0,31	14,2	0,206	0,210
120	0,31	15,0	0,161	0,164
150	0,31	17,0	0,129	0,132
185	0,41	18,7	0,106	0,108
240	0,41	21,4	0,081	0,0817
300	0,41	23,9	0,0641	0,0654

Insulating material characteristics

Characteristics	Insulating materials			
	PVC (Y)	PE (2Y)	XLPE (2X)	Halogen free(H)
Density	1.35-1.5	0.94-0.98	0.92	1.4-1.6
Break down voltage Kv/mm(20° C)	25	70	50	25
Dielectric constant	3.6-6	2.3	4-6	3.4-5
Working temperature (° C)	-30 to +70	-50 to +70	-35 to 90	-30 to +70
Flame resistance	Self extinguishing	flammable	flammable	Self extinguishing
Oxygen index (% O2)	23-42	<22	<22	<40
Heating value(Mj.kg)	17-25	42-44	42-44	17-22
Thermal conductivity ($w.k^{-1}.m^{-1}$)	0.17	0.3	0.3	0.17
Corrosive gases in case of fire	Hydrogen chloride	no	no	no
Tensile strength N/mm^2	10-25	10-20	12.5-20	8-13
Elongation at break %	130-350	Medium	300-400	150-250
Shore hardness	70-95 A	43-50 D	40-45 D	65-95 A
Abrasion resistance	Medium	400-600	Medium	Medium
Water absorption %	0.4	0.1	0.1	0.2-1.5
Halogen free	no	yes	yes	yes

Designation		XBN	ABN	BBN	CBN	DBN	EBN	FBN	GBN	HBN
d1 : flange diameter	mm	600	750	900	1050	1200	1400	1650	1900	2200
d2 : barrel diameter	mm	350	350	450	550	650	800	960	1200	1400
u : traverse diameter	mm	300	350	450	450	600	600	600	950	1000
H : overall width	mm	385	435	555	555	705	720	735	1150	1220
d3 : bare diameter	mm	42	82	82	82	82	82	82	82	82
Maximum load	Kg	200	500	700	800	1200	1500	2500	4000	5000
net weight	Kg	25	35	73	85	125	190	290	475	690



Capacity of drums

Type	600	750	900	1050	1200	1400	1650	1900	2200
	X	A	B	C	D	E	F	G	H
Distance to floor	50	50	50	50	50	50	50	50	50
D mm	Maximum cable lengths (m)								
8	425	1170	2240	3235					
10	267	800	1455	2070	3545				
12	190	520	980	1340	2395	3200			
14	131	365	720	1015	1800	2270	3390		
16	88	279	515	755	1380	1760	2540		
18	79	223	415	620	1040	1350	2005		
20		172	320	490	870	1135	1580	3250	
22		127	250	400	710	935	1320	2545	
24		121	230	315	585	780	1125	2130	3050
26		90	185	257	470	640	945	1795	2625
28			175	248	435	510	775	1485	2225
30			130	191	355	490	660	1410	1910
32				180	325	380	595	1175	1620
34				135	257	365	495	960	1530
36				125	244	287	470	930	1265
38				116	184	271	375	770	1230
40				114	184	271	375	715	1030
42				80	174	206	355	685	955
44					163	191	275	550	785
46					125	191	275	525	755
48					115	178	257	500	725
50					115	178	209	500	725
52					107	126	190	385	575
54					107	126	190	365	550
56					98	115	174	345	520
58						115	174	345	520
60						115	135	325	400
64							121	237	375
68							108	221	350
72							108	221	254
80									212
84									197
88									197
90									197

The maximum cable length

is calculated by the formula:

$$L_m = \underbrace{\left(\frac{u}{D}\right)}_{N1}\underbrace{\left(\frac{\frac{d_1-d_2}{2}-G}{D}\right)}_{N2}\left(d_2+N_2 D\right)\frac{\pi}{1000}$$

(G = Distance to floor)
N1 and N2 should be round down

Rigid copper and aluminium cables unarmoured 1 KV

TYPE	RESISTANCE (Ω /km)			Reactance (Ω / km) at 50 Hz - Lω	IMPEDANCE (Ω /km) at 50 Hz and 90° C for cos φ			
	Continuous current		alternative current at 90° C		1	0.8	0.5	0.3
	Rc 20° C	Rc 90° C						
Multi-pole copper cables								
1,5	12,10	15,43	15,43	0,107	15,43	12.41	7,81	4,73
2,5	7,41	9,45	9,45	0,100	9,45	7,62	4,81	2,93
4	4,61	5,88	5,88	0,094	5,88	4,76	3,02	1,85
6	3,08	3,93	3,93	0,088	3,93	3,19	2,04	1,26
10	1,83	2,33	2,33	0,0785	2,33	1,91	1,23	0,77
16	1,15	1,47	1,47	0,0754	1,47	1,22	0,80	0,51
25	0,727	0,927	0,927	0,0754	0,930	0,787	0,529	0,350
35	0,524	0,668	0,668	0,0754	0,672	0,580	0,399	0,272
50	0,387	0,493	0,494	0,0754	0,500	0,441	0,313	0,220
70	0,268	0,342	0,343	0,0722	0,350	0,318	0,234	0,172
95	0,193	0,246	0,247	0,0722	0,257	0,241	0,186	0,143
120	0,153	0,195	0,197	0,0722	0,210	0,201	0,161	0,128
150	0,124	0,158	0,16	0,0722	0,176	0,171	0,143	0,117
185	0,0991	0,1264	0,1291	0,0722	0,1479	0,1466	0,1271	0,1076
240	0,0754	0,0961	0,0997	0,0722	0,1232	0,1232	0,1124	0,0988
300	0,0601	0,0766	0,0812	0,0691	0,1066	0,1064	0,1004	0,0903
Single core copper cables								
50	0,387	0,493	0,493	0,0880	0,501	0,448	0,323	0,232
70	0,268	0,342	0,343	0,0848	0,353	0,325	0,245	0,184
95	0,193	0,246	0,247	0,0848	0,261	0,249	0,197	0,155
120	0,153	0,195	0,196	0,0816	0,212	0,206	0,169	0,137
150	0,124	0,158	0,160	0,0816	0,180	0,177	0,151	0,126
185	0,0991	0,1264	0,1285	0,0816	0,1522	0,1518	0,1349	0,1164
240	0,0754	0,0961	0,0991	0,0785	0,1264	0,1264	0,1175	0,1046
300	0,0601	0,0766	0,0803	0,0785	0,1123	0,1113	0,1081	0,0990
400	0,0470	0,0599	0,0646	0,0785	0,1017	0,0988	0,1003	0,0943
Multi core aluminum cables								
35	0,868	1,113	1,113	0,0754	1,115	0,936	0,622	0,406
50	0,641	0,822	0,822	0,0754	0,825	0,703	0,476	0,318
70	0,443	0,568	0,569	0,0722	0,574	0,499	0,347	0,240
95	0,320	0,410	0,411	0,0722	0,418	0,372	0,268	0,192
120	0,253	0,324	0,325	0,0722	0,333	0,304	0,225	0,166
150	0,206	0,264	0,265	0,0722	0,275	0,255	0,195	0,148
185	0,164	0,210	0,212	0,0722	0,224	0,213	0,168	0,132
240	0,125	0,160	0,162	0,0691	0,177	0,171	0,141	0,115
300	0,100	0,128	0,131	0,0691	0,148	0,146	0,125	0,105
Single core aluminum cables								
50	0,641	0,822	0,822	0,0880	0,827	0,710	0,487	0,330
70	0,443	0,568	0,568	0,0848	0,574	0,505	0,357	0,251
95	0,320	0,410	0,411	0,0848	0,420	0,380	0,279	0,204
120	0,253	0,324	0,325	0,0816	0,335	0,309	0,233	0,175
150	0,206	0,264	0,265	0,0816	0,277	0,261	0,203	0,157
185	0,164	0,210	0,212	0,0816	0,227	0,218	0,176	0,141
240	0,125	0,160	0,162	0,0785	0,180	0,177	0,149	0,124
300	0,1000	0,1282	0,1304	0,0785	0,1522	0,1515	0,1332	0,1140
400	0,0778	0,0997	0,1027	0,0785	0,1293	0,1293	0,1193	0,1057

Rigid copper and aluminium cables 1 KV armoured

TYPE	RESISTANCE (Ω /km) Continuous current Rc 20°C	Rc 90°C	alternative current	REACTANCE (Ω / km) at 50 Hz - Lω	IMPEDANCE (Ω /km) at 50 Hz and 90°C for cos φ 1	0.8	0.5	0.3
Multi core copper cables								
1,5	12,10	15,43	15,43	0,122	15,43	12,42	7,82	4,74
2.,5	7,41	9,45	9,45	0,116	9,45	7,63	4,82	2,95
4	4,61	5,88	5,88	0,110	5,88	4,77	3,03	1,87
6	3,08	3.93	3,93	0,100	3,93	3,20	2,05	1,27
10	1,83	2,33	2,33	0,094	2,34	1,92	1,25	0,790
16	1,15	1,47	1,47	0,0911	1,47	1,23	0,81	0,53
25	0,727	0,927	0,927	0,0911	0,931	0,796	0,542	0,365
35	0,524	0,668	0,668	0,0911	0,674	0,589	0,413	0,287
50	0,387	0,493	0,494	0,0879	0,502	0,448	0,323	0,232
70	0,268	0,342	0,343	0,0879	0,354	0,327	0,247	0,187
95	0,193	0,246	0,247	0,0879	0,262	0,250	0,200	0,158
120	0,153	0,195	0,197	0,0879	0,216	0,210	0,175	0,143
150	0,124	0,158	0,16	0,0879	0,183	0,181	0,156	0,132
185	0,0991	0,1264	0,1291	0,0879	0,1562	0,1560	0,1407	0,1226
240	0,0754	0,0961	0,0997	0,0879	0,1330	0,1326	0,1260	0,1138
300	0,0601	0,0766	0,0812	0,0848	0,1174	0,1158	0,1140	0,1053
Multi core aluminium cables								
35	0,868	1,113	1,113	0,0911	1,117	0,945	0,635	0,421
50	0,641	0,822	0,822	0,0879	0,827	0,710	0,487	0,330
70	0,443	0,568	0,569	0,0879	0,576	0,508	0,361	0,255
95	0,320	0,410	0,411	0,0879	0,421	0,382	0,282	0,207
120	0,253	0,324	0,325	0,0879	0,337	0,313	0,239	0,181
150	0,206	0,264	0,265	0,0879	0,279	0,265	0,209	0,163
185	0,164	0,210	0,212	0,0879	0,229	0,222	0,182	0,147
240	0,125	0,160	0,162	0,0879	0,185	0,183	0,157	0,133
300	0,100	0,128	0,131	0,0848	0,156	0,156	0,139	0,120

Flexible cables 450/750 V

TYPE	RESISTANCE (Ω /km) Continuous current Rc 20°C	Rc 90°C	alternative current	REACTANCE (Ω / km) at 50 Hz - Lω	IMPEDANCE (Ω /km) at 50 Hz and 90°C for cos φ 1	0.8	0.5	0.3
Multi core copper cables								
1	19,5	24,9	24,9	0,110	24,9	20	12,5	7,6
1,5	13,3	17,0	17,0	0,104	17,0	13,6	8,6	5,2
2,5	7,98	10,18	10,18	0,100	10,18	8,2	5,17	3,15
4	4,95	6,31	6,31	0,094	6,31	5,11	3,24	1,98
6	3,30	4,21	4,21	0,091	4,21	3,42	2,18	1,35
10	1,91	2,44	2,44	0,0879	2,44	2,00	1,29	0,81
16	1,21	1,54	1,54	0,0816	1,55	1,28	0,84	0,54
25	0,780	0,995	0,995	0,0816	0,998	0,845	0,568	0,376
35	0,554	0,706	0,706	0,0785	0,711	0,612	0,421	0,287
50	0,386	0,492	0,493	0,0785	0,499	0,442	0,315	0,223
70	0,272	0,347	0,347	0,0785	0,356	0,325	0,242	0,179
95	0,206	0,263	0,264	0,0785	0,275	0,258	0,200	0,154
Multi core aluminium cables								
50	0,386	0,492	0,492	0,0973	0,502	0,452	0,330	0,240
70	0,272	0,347	0,348	0,0973	0,361	0,337	0,258	0,197
95	0,206	0,263	0,264	0,0973	0,281	0,269	0,216	0,172
120	0,161	0,205	0,206	0,0942	0,227	0,222	0,185	0,152
150	0,129	0,164	0,166	0,0911	0,189	0,187	0,162	0,137
185	0,106	0,135	0,137	0,0911	0,165	0,164	0,147	0,128
240	0,0801	0,1021	0,1044	0,0911	0,1385	0,1382	0,1311	0,1182
300	0,0641	0,0817	0,0846	0,0879	0,122	0,1204	0,1184	0,1092

Introduction

Cable sizing methods do differ across international standards (e.g. IEC, NEC, BS, etc) and some standards emphasise certain things over others. However the general principles underlying any cable sizing calculation do not change. In this article, a general methodology for sizing cables is first presented and then the specific international standards are introduced.

Why do the calculation?

The proper sizing of an electrical (load bearing) cable is important to ensure that the cable can:

- Operate continuously under full load without being damaged.
- Withstand the worst short circuits currents flowing through the cable.
- Provide the load with a suitable voltage (and avoid excessive voltage drops).
- (optional) Ensure operation of protective devices during an earth fault.

When to do the calculation?

This calculation can be done individually for each power cable that needs to be sized, or alternatively, it can be used to produce cable sizing waterfall charts for groups of cables with similar characteristics (e.g. cables installed on ladder feeding induction motors).

General Methodology

All cable sizing methods more or less follow the same basic six step process:

1- Gathering data about the cable, its installation conditions, the load that it will carry, etc

2- Determine the minimum cable size based on continuous current carrying capacity.

3- Determine the minimum cable size based on voltage drop considerations.

4- Determine the minimum cable size based on short circuit temperature rise.

5- Determine the minimum cable size based on earth fault loop impedance.

6- Select the cable based on the highest of the sizes calculated in step 2, 3, 4 and 5.

Step 1: Data Gathering

The first step is to collate the relevant information that is required to perform the sizing calculation. Typically, you will need to obtain the following data:

Load Details

The characteristics of the load that the cable will supply, which includes: Load type: motor or feeder.

Three phase, single phase or DC

System / source voltage

Full load current (A) - or calculate this if the load is defined in terms of power (kW)

Full load power factor (pu)

Locked rotor or load starting current (A).

Starting power factor (pu)

Distance / length of cable run from source to load - this length should be as close as possible to the actual route of the cable and include enough contingency for vertical drops / rises and termination of the cable tails.

Cable Construction

The basic characteristics of the cable's physical construction, which includes:

- Conductor material - normally copper or aluminium
- Conductor shape - e.g. circular or shaped.
- Conductor type - e.g. stranded or solid.
- Conductor surface coating - e.g. plain (no coating), tinned, silver or nickel.
- Insulation type - e.g. PVC, XLPE, EPR.
- Number of cores - single core or multicore (e.g. 2C, 3C or 4C).

Installation Conditions

How the cable will be installed, which includes:

- Above ground or underground.
- Installation / arrangement - e.g. for underground cables, is it directly buried or buried in conduit? for above ground cables, is it installed on cable tray / ladder, against a wall, in air, etc.
- Ambient or soil temperature of the installation site.
- Cable bunching, i.e. the number of cables that are bunched together.
- Cable spacing, i.e. whether cables are installed touching or spaced
- Soil thermal resistivity (for underground cables)
- Depth of laying (for underground cables)
- For single core three-phase cables, are the cables installed in trefoil or laid flat?

Step 2: Cable Selection Based on Current Rating

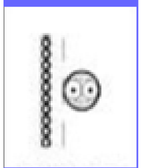
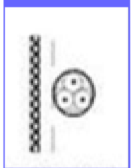
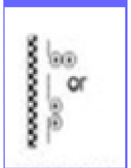
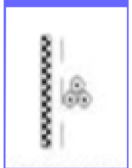
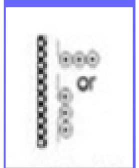
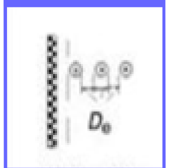
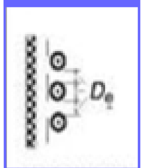
Current flowing through a cable generates heat through the resistive losses in the conductors, dielectric losses through the insulation and resistive losses from current flowing through any cable screens / shields and armouring.

The component parts that make up the cable (e.g. conductors, insulation, bedding, sheath, armour, etc) must be capable of withstanding the temperature rise and heat emanating from the cable. The current carrying capacity of a cable is the maximum current that can flow continuously through a cable without damaging the cable's insulation and other components (e.g. bedding, sheath, etc). It is sometimes also referred to as the continuous current rating or ampacity of a cable.

Cables with larger conductor cross-sectional areas (i.e. more copper or aluminium) have lower resistive losses and are able to dissipate the heat better than smaller cables. Therefore a 16 mm2 cable will have a higher current carrying capacity than a 4 mm^2 cable.

Base Current Ratings

Table A.52-10 (52-C9) - Current-carrying capacities in amperes for installation methods E, F and G of table A.52-1 (52-B1) - PVC insulation/Copper conductors
Conductor temperature: 70 ° C/Reference ambient temperature: 30 ° C

Nominal cross-selectional area of conductor mm²	Installation methods of table A.52-1						
	Multi-core cables		Single-core cables				
	Two loaded conductors	Three loaded conductors	Two loaded conductors touching	Three loaded conductors trefoil	Three loaded conductors, flat		
					Touching	Spaced	
						Horizontal	Vertical
							
	Method E	Method E	Method F	Method F	Method F	Method G	Method G
1	2	3	4	5	6	7	8
1,5	22	18,5	-	-	-	-	-
2,5	30	25	-	-	-	-	-
4	40	34	-	-	-	-	-
6	51	43	-	-	-	-	-
10	70	60	-	-	-	-	-
16	94	80	-	-	-	-	-
25	119	101	131	110	114	146	130
35	148	126	162	137	143	181	162
50	180	153	196	167	174	219	197
70	232	196	251	216	225	281	254
95	282	238	304	264	275	341	311
120	328	276	352	308	321	396	362
150	379	319	406	356	372	456	419
185	434	364	463	409	427	521	480
240	514	430	546	485	507	615	569
300	593	497	629	561	587	709	659
400	-	-	754	656	689	852	795
500	-	-	868	749	789	982	920
630	-	-	1 005	855	905	1 138	1 070

NOTE: Circular conductors are assumed for sizes up to and including 16 mm². Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

Table 1. Example of base current rating table (Excerpt from IEC 60364-5-52)

International standards and manufacturers of cables will quote base current ratings of different types of cables in tables such as the one shown on the right. Each of these tables pertain to a specific type of cable construction (e.g. copper conductor, PVC insulated, 0.6/1kV voltage grade, etc) and a base set of installation conditions (e.g. ambient temperature, installation method, etc). It is important to note that the current ratings are only valid for the quoted types of cables and base installation conditions.
In the absence of any guidance, the following reference based current ratings may be used.

Installed Current Ratings

When the proposed installation conditions differ from the base conditions, derating (or correction) factors can be applied to the base current ratings to obtain the actual installed current ratings.

International standards and cable manufacturers will provide derating factors for a range of installation conditions, for example ambient / soil temperature, grouping or bunching of cables, soil thermal resistivity, etc. The installed current rating is calculated by multiplying the base current rating with each of the derating factors, i.e.

$$I_c = I_b.k_d$$

where

I_c is the installed current rating (A)

I_b is the base current rating (A)

k_d are the product of all the derating factors

For example, suppose a cable had an ambient temperature derating factor of k_{amb} = 0.94 and a grouping derating factor of k_g = 0.85, then the overall derating factor k_d = 0.94x0.85 = 0.799. For a cable with a base current rating of 42A, the installed current rating would be I_c = 0.799x42 = 33.6A.

In the absence of any guidance, the following reference derating factors may be used.

Cable Selection and Coordinaton with Protective Devices

Feeders

When sizing cables for non-motor loads, the upstream protective device (fuse or circuit breaker) is typically selected to also protect the cable against damage from thermal overload. The protective device must therefore be selected to exceed the full load current, but not exceed the cable's installed current rating, i.e. this inequality must be met:

$$I_l \leqslant I_p \leqslant k_c$$

Where

I_l is the full load current (A)

I_p is the protective device rating (A)

k_c is the installed cable current rating (A)

Motors

Motors are normally protected by a separate thermal overload (TOL) relay and therefore the upstream protective device (e.g. fuse or circuit breaker) is not required to protect the cable against overloads. As a result, cables need only to be sized to cater for the full load current of the motor, i.e.

$$I_l \leqslant I_c$$

Where

I_l is the full load current (A)

I_c is the installed cable current rating (A)

Of course, if there is no separate thermal overload protection on the motor, then the protective device needs to be taken into account as per the case for feeders above.

Step 3: Voltage Drop

A cable's conductor can be seen as an impedance and therefore whenever current flows through a cable, there will be a voltage drop across it, which can be derived by Ohm's Law (i.e. V = IZ). The voltage drop will depend on two things:

- Current flow through the cable – the higher the current flow, the higher the voltage drop.

- Impedance of the conductor – the larger the impedance, the higher the voltage drop.

Cable Impedances

The impedance of the cable is a function of the cable size (cross-sectional area) and the length of the cable. Most cable manufacturers will quote a cable's resistance and reactance in Ω/km. The following typical cable impedances for low voltage AC and DC single core and multicore cables can be used in the absence of any other data.

Calculating Voltage Drop

For AC systems, the method of calculating voltage drops based on load power factor is commonly used. Full load currents are normally used, but if the load has high startup currents (e.g. motors), then voltage drops based on starting current (and power factor if applicable) should also be calculated.

For a three phase system:

$$V_{3\phi} = \frac{\sqrt{3}I\,(R_c\cos\phi + X_c\sin\phi)\,L}{1000}$$

Where

$V_{3\phi}$ is the three phase voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the ac resistance of the cable (Ω/km)

X_c is the ac reactance of the cable (Ω/km)

$\cos\phi$ is the load power factor (pu)

L is the length of the cable (m)

For a single phase system:

$$V_{1\phi} = \frac{2I\,(R_c\cos\phi + X_c\sin\phi)\,L}{1000}$$

Where

$V_{1\phi}$ is the single phase voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the ac resistance of the cable (Ω/km)

X_c is the ac reactance of the cable (Ω/km)

$\cos\phi$ is the load power factor (pu)

L is the length of the cable (m)

For a DC system: $V_{dc} = \dfrac{2I\,R_c\,L}{1000}$

Where

V_{dc} is the dc voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the dc resistance of the cable (Ω/km)

L is the length of the cable (m)

Maximum Permissible Voltage Drop

It is customary for standards (or clients) to specify maximum permissible voltage drops, which is the highest voltage drop that is allowed across a cable. Should your cable exceed this voltage drop, then a larger cable size should be selected.

Maximum voltage drops across a cable are specified because load consumers (e.g. appliances) will have an input voltage tolerance range. This means that if the voltage at the appliance is lower than its rated minimum voltage, then the appliance may not operate correctly.

In general, most electrical equipment will operate normally at a voltage as low as 80% nominal voltage. For example, if the nominal voltage is 230VAC, then most appliances will run at >184VAC. Cables are typically sized for a more conservative maximum voltage drop, in the range of 5 – 10% at full load.

Calculating Maximum Cable Length due to Voltage Drop

It may be more convenient to calculate the maximum length of a cable for a particular conductor size given a maximum permissible voltage drop (e.g. 5% of nominal voltage at full load) rather than the voltage drop itself. For example, by doing this it is possible to construct tables showing the maximum lengths corresponding to different cable sizes in order to speed up the selection of similar type cables.

The maximum cable length that will achieve this can be calculated by re-arranging the voltage drop equations and substituting the maximum permissible voltage drop (e.g. 5% of 415V nominal voltage = 20.75V). For a three phase system:

$$L_{max} = \frac{1000\,V_{3\phi}}{\sqrt{3}I\,(R_c\cos\phi + X_c\sin\phi)}$$

Where

L_{max} is the maximum length of the cable (m)

$V_{3\phi}$ is the maximum permissible three phase voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the ac resistance of the cable (Ω/km)

X_c is the ac reactance of the cable (Ω/km)

$\cos\phi$ is the load power factor (pu)

For a single phase system:

$$L_{max} = \frac{1000\,V_{1\phi}}{2I\,(R_c\cos\phi + X_c\sin\phi)}$$

Where

L_{max} is the maximum length of the cable (m)

$V_{1\phi}$ is the maximum permissible single phase voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the ac resistance of the cable (Ω/km)

X_c is the ac reactance of the cable (Ω/km)

$\cos\phi$ is the load power factor (pu)

For a DC system:

$$L_{max} = \frac{1000\ V_{dc}}{2I\ R_c}$$

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Where

L_{max} is the maximum length of the cable (m)

V_{dc} is the maximum permissible dc voltage drop (V)

I is the nominal full load or starting current as applicable (A)

R_c is the dc resistance of the cable (Ω/km)

L is the length of the cable (m)

Step 4: Short Circuit Temperature Rise

During a short circuit, a high amount of current can flow through a cable for a short time. This surge in current flow causes a temperature rise within the cable. High temperatures can trigger unwanted reactions in the cable insulation, sheath materials and other components, which can prematurely degrade the condition of the cable. As the cross-sectional area of the cable increases, it can dissipate higher fault currents for a given temperature rise. Therefore, cables should be sized to withstand the largest short circuit that it is expected to see.

Minimum Cable Size Due to Short Circuit Temperature Rise

The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

Where

A is the minimum cross-sectional area of the cable (mm2)

i is the prospective short circuit current (A)

t is the duration of the short circuit (s)

k is a short circuit temperature rise constant

The temperature rise constant is calculated based on the material properties of the conductor and the initial and final conductor temperatures (see the derivation here). Different international standards have different treatments of the temperature rise constant, but by way of example, IEC 60364-5-54 calculates it as follows:

$$k = 226\sqrt{\ln\left(1 + \frac{\theta_f - \theta_i}{234.5 + \theta_i}\right)}$$

(for copper conductors)

$$k = 148\sqrt{\ln\left(1 + \frac{\theta_f - \theta_i}{228 + \theta_i}\right)}$$

(for copper conductors)

Where

θ_i is the initial conductor temperature (deg C)

θ_i is the final conductor temperature (deg C)

Initial and Final Conductor Temperatures

The initial conductor temperature is typically chosen to be the maximum operating temperature of the cable. The final conductor temperature is typically chosen to be the limiting temperature of the insulation. In general, the cable's insulation will determine the maximum operating temperature and limiting temperatures.

As a rough guide, the following temperatures are common for the different insulation materials:

Material	Max Operating Temp. °C	Limiting Temp. °C
PVC	75	160
EPR	90	250
XLPE	90	250

Maximum Permissible Voltage Drop

It is customary for standards (or clients) to specify maximum permissible voltage drops, which is the highest voltage drop that is allowed across a cable. Should your cable exceed this voltage drop, then a larger cable size should be selected.

Maximum voltage drops across a cable are specified because load consumers (e.g. appliances) will have an input voltage tolerance range. This means that if the voltage at the appliance is lower than its rated minimum voltage, then the appliance may not operate correctly.

In general, most electrical equipment will operate normally at a voltage as low as 80% nominal voltage. For example, if the nominal voltage is 230VAC, then most appliances will run at >184VAC. Cables are typically sized for a more conservative maximum voltage drop, in the range of 5 – 10% at full load.

Calculating Maximum Cable Length due to Voltage Drop

It may be more convenient to calculate the maximum length of a cable for a particular conductor size given a maximum permissible voltage drop (e.g. 5% of nominal voltage at full load) rather than the voltage drop itself. For example, by doing this it is possible to construct tables showing the maximum lengths corresponding to different cable sizes in order to speed up the selection of similar type cables. The maximum cable length that will achieve this can be calculated by re-arranging the voltage drop equations and substituting the maximum permissible voltage drop (e.g. 5% of 415V nominal voltage = 20.75V). For a three phase system:

Short Circuit Energy

The short circuit energy is normally chosen as the maximum short circuit that the cable could potentially experience. However for circuits with current limiting devices (such as HRC fuses), then the short circuit energy chosen should be the maximum prospective let-through energy of the protective device, which can be found from manufacturer data.

Step 5: Earth Fault Loop Impedance

Sometimes it is desirable (or necessary) to consider the earth fault loop impedance of a circuit in the sizing of a cable. Suppose a bolted earth fault occurs between an active conductor and earth. During such an earth fault, it is desirable that the upstream protective device acts to interrupt the fault within a maximum disconnection time so as to protect against any inadvertent contact to exposed live parts.

Ideally the circuit will have earth fault protection, in which case the protection will be fast acting and well within the maximum disconnection time. The maximum disconnection time is chosen so that a dangerous touch voltage does not persist for long enough to cause injury or death. For most circuits, a maximum disconnection time of 5s is sufficient, though for portable equipment and socket outlets, a faster disconnection time is desirable (i.e. <1s and will definitely require earth fault protection).

However for circuits that do not have earth fault protection, the upstream protective device (i.e. fuse or circuit breaker) must trip within the maximum disconnection time. In order for the protective device to trip, the fault current due to a bolted short circuit must exceed the value that will cause the protective device to act within the maximum disconnection time.

For example, suppose a circuit is protected by a fuse and the maximum disconnection time is 5s, then the fault current must exceed the fuse melting current at 5s (which can be found by cross-referencing the fuse time-current curves). By simple application of Ohm's law:

$$I_A = \frac{V_o}{Z_s}$$

Where

I_A is the earth fault current required to trip the protective device within the minimum disconnection time (A)

V_o is the phase to earth voltage at the protective device (V)

Z_s is the impedance of the earth fault loop (Ω)

It can be seen from the equation above that the impedance of the earth fault loop must be sufficiently low to ensure that the earth fault current can trip the upstream protection.

The Earth Fault Loop

The earth fault loop can consist of various return paths other than the earth conductor, including the cable armour and the static earthing connection of the facility. However for practical reasons, the earth fault loop in this calculation consists only of the active conductor and the earth conductor.

The earth fault loop impedance can be found by:

$$Z_s = Z_c + Z_e$$

Where

Z_s is the earth fault loop impedance (Ω)

Z_c is the impedance of the active conductor (Ω)

Z_e is the impedance of the earth conductor (Ω)

Assuming that the active and earth conductors have identical lengths, the earth fault loop impedance can be calculated as follows:

$$Z_s = \frac{L}{1000}\sqrt{(R_c + R_e)^2 + (X_c + X_e)^2}$$

Where

L is the length of the cable (m)

R_c and R_e are the ac resistances of the active and earth conductors respectively (Ω/km)

X_c and X_e are the reactances of the active and earth conductors respectively (Ω/km)

Maximum Cable Length

The maximum earth fault loop impedance can be found by re-arranging the equation above

$$Z_{s\,max} = \frac{V_o}{I_A}$$

Where

Z_s is the maximum earth fault loop impedance (Ω)

V_o is the phase to earth voltage at the protective device (V)

I_A is the earth fault current required to trip the protective device within the disconnection time (A)

The maximum cable length can therefore be calculated by the following: :

$$L_{max} = \frac{1000\,V_o}{I_A\sqrt{(R_c + R_e)^2 + (X_c + X_e)^2}}$$

Where

L_{max} is the maximum cable length (m)

V_o is the phase to earth voltage at the protective device (V)

I_A is the earth fault current required to trip the protective device within the minimum disconnection time (A)

R_c and R_e are the ac resistances of the active and earth conductors respectively (Ω/km)

X_c and X_e are the reactances of the active and earth conductors respectively (Ω/km)

Note that the voltage V_o at the protective device is not necessarily the nominal phase to earth voltage, but usually a lower value as it can be downstream of the main busbars. This voltage is commonly represented by applying some factor to the nominal voltage. A conservative value of C = 0.8 can be used so that:

$$V_o = CV_n = 0.8\,V_n$$

Where V_n is the nominal phase to earth voltage (V)

Worked Example

In this example, we will size a cable for a 415V, 30kW three-phase motor from the MCC to the field.

Step 1: Data Gathering

The following data was collected for the cable to be sized:

- Cable type: Cu/PVC/GSWB/PVC, 3C+E, 0.6/1kV
- Operating temperature: 75C
- Cable installation: above ground on cable ladder bunched together with 3 other cables on a single layer and at 30C ambient temperature
- Cable run: 90m (including tails)
- Motor load: 30kW, 415V three phase, full load current = 61A, power factor = 0.85
- Protection: aM fuse of rating = 80A, max prospective fault I^2t = 90 A²s , 5s melt time = 550A

Step 2: Cable Selection Based on Current Rating

Suppose the ambient temperature derating is 0.89 and the grouping derating for 3 bunched cables on a single layer is 0.82. The overall derating factor is 0.89 X 0.82 = 0.7298. Given that a 16 mm² and 25 mm² have base current ratings of 80A and 101A respectively (based on Reference Method E), which cable should be selected based on current rating considerations?

The installed current ratings for 16 mm² and 25 mm² is 0.7298 X 80A = 58.38A and 0.7298 X 101A = 73.71A respectively. Given that the full load current of the motor is 61A, then the installed current rating of the 16 mm² cable is lower than the full load current and is not suitable for continuous use with the motor. The 25 mm² cable on the other hand has an installed current rating that exceeds the motor full load current, and is therefore the cable that should be selected.

Step 3: Voltage Drop

Suppose a 25 mm² cable is selected. If the maximum permissible voltage drop is 5%, is the cable suitable for a run length of 90m?

A 25 mm² cable has an ac resistance of 0.884 Ω/km and an ac reactance of 0.0895 Ω/km. The voltage drop across the cable is:

$$V_d = \frac{90}{1000} \times \sqrt{3} \times 61 \times \left[0.884 \times 0.85 + 0.0895 \left(\cos^{-1}(0.85) \right) \right] = 7.593V$$

A voltage drop of 7.593V is equivalent to $\frac{7.593}{415} = 1.83\%$

which is lower than the maximum permissible voltage

dorp of 5%. Therefore the cable is suitable for the motor based on voltage drop considerations.

Step 4: Short Circuit Temperature Rise

The cable is operating normally at 75C and has a prospective fault capacity (I^2t) of 90,000 A2s. What is the minimum size of the cable based on short circuit temperature rise?

PVC has a limiting temperature of 160C. Using the IEC formula, the short circuit temperature rise constant is 111.329. The minimum cable size due to short circuit temperature rise is therefore:

$$A = \frac{\sqrt{90,000}}{111.329} = 2.695\text{mm}^2$$

In this example, we also use the fuse for earth fault protection and it needs to trip within 5s, which is at the upperend of the adiabatic period where the short circuit temperature rise equation is still valid. Therefore, it's a good idea to also check that the cable can withstand the short circuit temperature rise for for a 5s fault. The 80A motor fuse has a 5s melting current of 550A. The short circuit temperature rise is thus:

$$A = \frac{\sqrt{550^2 \times 5}}{111.329} = 11.047\text{mm}^2$$

Therefore, our 25 mm² cable is still suitable for this application.

Step 5: Earth Fault Loop Impedance

Suppose there is no special earth fault protection for the motor and a bolted single phase to earth fault occurs at the motor terminals. Suppose that the earth conductor for our 25 mm² cable is 10 mm². If the maximum disconnection time is 5s, is our 90m long cable suitable based on earth fault loop impedance?

The 80A motor fuse has a 5s melting current of 550A. The ac resistances of the active and earth conductors are 0.884 Ω/km and 2.33 Ω/km) respectively. The reactances of the active and earth conductors are 0.0895 Ω/km and 0.0967 Ω/km) respectively.

The maximum length of the cable allowed is calculated as:

$$L_{max} = \frac{(1000)(0.8)(240)}{550\sqrt{(0.884 + 2.33)^2 + (0.0895 + 0.0967)^2}} = 108.43m$$

The cable run is 90m and the maximum length allowed is 108m, therefore our cable is suitable based on earth fault loop impedance. In fact, our 25 mm² cable has passed all the tests and is the size that should be selected.

Waterfall Charts

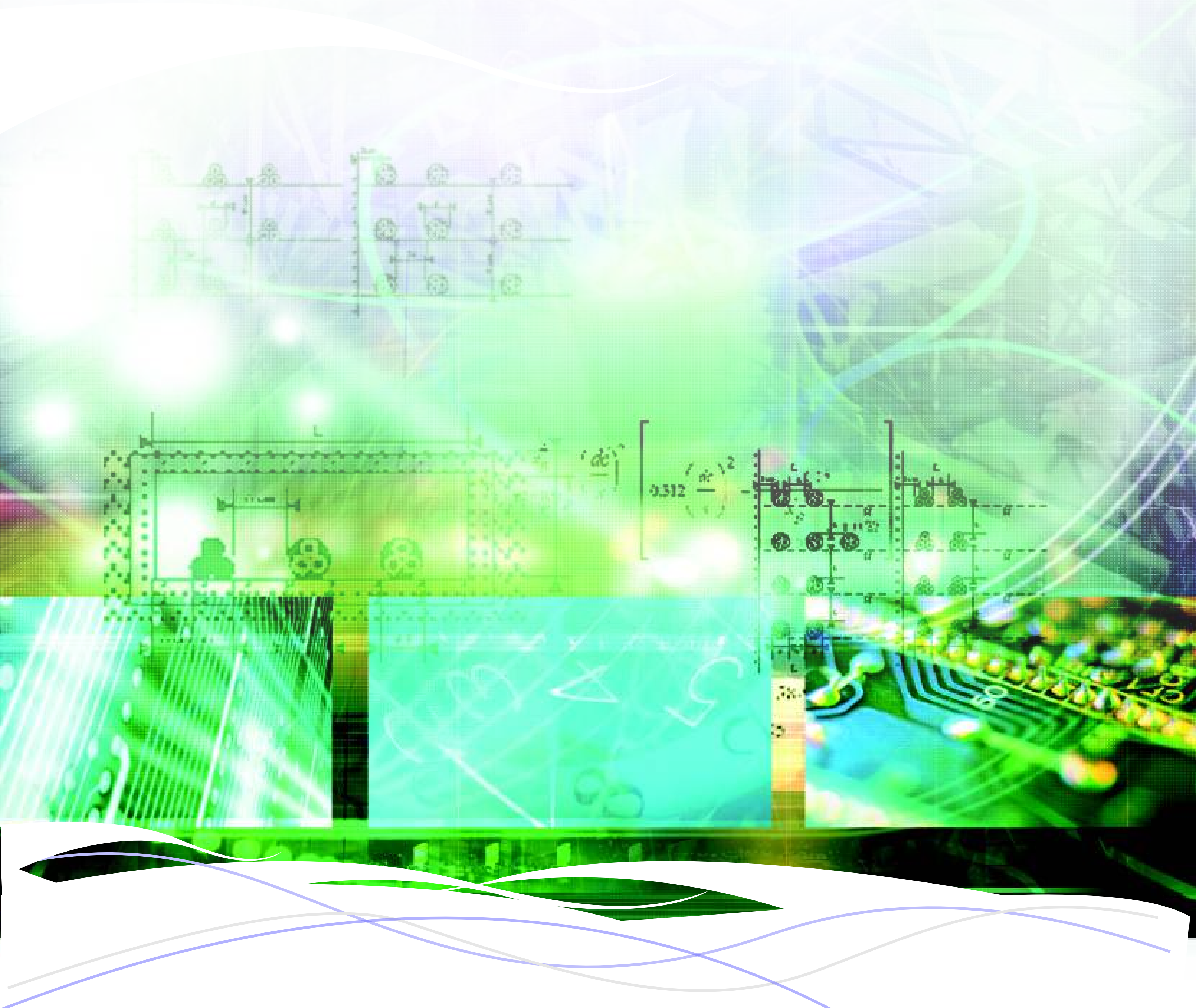
Load Rating (kw)	gMFuse Fating (A)	415V 3-Phase Motor Cable Selection Chart (15% Starting, 5% Full Load Voltage Drop)														
		2.5	4	6	10	16	25	35	50	70	95	120	150	185	2x95	Conductors Size (mm²)
		19.01	24.85	31.43	41.67	54.09	70.18	84.07	102.34	127.93	153.51	175.44	197.37	226.61	307.02	Current Rating (A)
1.1	4															
1.5	6		355	407												
2.2	10		240	275	449											
3	10		240	275	449											
4	16		130	149	243	370	411									
5.5	16		130	149	243	370	411									
7.5	20		104	119	194	296	329									
11	32		78	90	146	222	246									
15	40			129	215	335	487									
18.5	50				174	272	395									
22	63					229	332	427								
30	80						244	313	390	495						
37	100							254	316	401	480					
45	125								260	330	394	447	488			
55	160									270	323	366	399	434		
75	200										237	268	293	318	473	
90	200											224	244	265	394	
110	250													217	323	
132	355														269	
150	400														237	
160	400															
185	500															

Table 2. Example of a cable waterfall chart

Sometimes it is convenient to group together similar types of cables (for example, 415V PVC motor cables installed on cable ladder) so that instead of having to go through the laborious exercise of sizing each cable separately, one can select a cable from a pre-calculated chart.

These charts are often called "waterfall charts" and typically show a list of load ratings and the maximum of length of cable permissible for each cable size. Where a particular cable size fails to meet the requirements for current carrying capacity or short circuit temperature rise, it is blacked out on the chart (i.e. meaning that you can't choose it).

Preparing a waterfall chart is common practice when having to size many like cables and substantially cuts down the time required for cable selection.



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