



## Appendix:

### I Additional Electrical Data

### II Tests on Power and Control Cables

### III General Information



## Appendix

### I Additional Electrical Data

Table 1: Resistance

Nominal cross-sectional area  nom (mm <sup>2</sup> )	DC resistance at 20 °C (copper)  max (Ω/km)	Max. Active resistance (copper)	
		at 70 °C for PVC (Ω/km)	at 90 °C for XLPE (Ω/km)
1.5	12.1	14.5	15.4
2.5	7.41	8.87	9.45
4	4.61	5.52	5.88
6	3.08	3.69	3.93
10	1.83	2.19	2.33
16	1.15	1.38	1.47
25	0.727	0.872	0.927
35	0.524	0.628	0.669
50	0.387	0.464	0.494
70	0.268	0.322	0.342
95	0.193	0.233	0.247
120	0.153	0.186	0.196
150	0.124	0.152	0.160
185	0.0991	0.122	0.128
240	0.0754	0.0948	0.0988
300	0.0601	0.0774	0.0800
400	0.0470	0.0619	0.0641
500	0.0366	0.0495	0.0514
630	0.0283	0.0405	0.0421
800	0.0221	0.0332	0.0350
1000	0.0176	0.0273	0.0302

**Table 2: Reactance**

Nominal cross-sectional area	Reactance <sup>1)</sup> (inductive) per conductor at 50 Hz for U <sub>0</sub> /U 0.6/1 kV			
	PVC insulated		XLPE insulated	
	single core <sup>2)</sup> nom. (Ω/km)	multicore nom. (Ω/km)	single core <sup>2)</sup> nom. (Ω/km)	multicore nom. (Ω/km)
1.5	----	0.119	----	0.114
2.5	----	0.114	----	0.105
4	----	0.110	----	0.098
6	----	0.103	----	0.094
10	----	0.097	----	0.088
16	0.117	0.091	0.118	0.084
25	0.110	0.088	0.112	0.083
35	0.105	0.085	0.107	0.081
50	0.102	0.085	0.104	0.080
70	0.097	0.081	0.101	0.079
95	0.095	0.081	0.098	0.077
120	0.092	0.079	0.096	0.077
150	0.091	0.079	0.096	0.077
185	0.090	0.079	0.096	0.077
240	0.088	0.079	0.094	0.077
300	0.088	0.079	0.093	0.077
400	0.086	0.079	0.093	0.076
500	0.085	----	0.093	----
630	0.084	----	0.090	----
800	0.083	----	0.092	----

<sup>1)</sup> Values for steel wire armoured cables. For unarmoured cables the values can be reduced by approx. 10 %.

<sup>2)</sup> Cables with aluminium wire armouring and in touching trefoil arrangement.

**Table 3: Voltage Drop**

Nominal cross-sectional area (mm <sup>2</sup> )	DC-System (mV/A/m)	Single-phase AC-System (mV/A/m)	Three-phase AC-System (mV/A/m)
1.5	24.2	27.9	24.1
2.5	14.3	17.1	14.8
4	9.0	10.7	9.3
6	6.0	7.2	6.2
10	3.6	4.3	3.7
16	2.3	2.8	2.4
25	1.5	1.8	1.5
35	1.1	1.3	1.1
50	0.8	0.96	0.85
70	0.6	0.70	0.60
95	0.4	0.55	0.45
120	0.3	0.45	0.35
150	0.25	0.35	0.31
185	0.20	0.30	0.26
240	0.15	0.25	0.22
300	0.12	0.22	0.19
400	0.10	0.19	0.17

The voltage drop in a circuit, of which the cable forms a part, should not exceed 3 - 5% of the nominal voltage; e.g. 20.0 volts (5%) for a three-phase 400 volts supply. The above mentioned voltage drop is tabulated for a current of 1 ampere for a 1 metre run. For any cable length, the values need to be multiplied by the length of the cable (in metres) and by the current (in amperes).

**Example:**

Formula for the calculated voltage drop in mV/A/m:

$$e_{cal} = \frac{\text{permissible voltage drop (e) x 1000}}{\text{current (I) x length (l)}}$$

Installation length (l): 300 m  
 Current (I) to carry: 80 A  
 Nominal voltage (U): 400 V (Three-phase AC)  
 Permissible voltage drop (e): 20.0 V (5% of 400 V)

$$e_{cal} = \frac{20.0 \text{ V} \times 1000}{80 \text{ A} \times 300 \text{ m}} = 0.83 \text{ mV/A/m}$$

Select a cross-section, such that the voltage drop is equal to or less than 0.83 mV/A/m from table 3. It has to be ensured that the selected cross-section will carry the current (see pages H5 up to H7).

The corresponding cross-section will be 50 mm<sup>2</sup>.

**Table 4: Current Ratings (AC) - U<sub>0</sub> / U 0.6 / 1 kV  
Copper conductors laid in air**

Nominal cross-sectional area  nom. (mm <sup>2</sup> )	 <sup>1)</sup>		 <sup>2)</sup>		 <sup>2)</sup>			
	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)
1.5	27	33	20	24	21	27		
2.5	35	43	26	32	28	36		
4	47	57	34	42	37	47		
6	59	72	43	53	47	59		
10	81	99	59	73	64	81		
16	107	131	78	97	84	109		
25	144	177	105	132	114	146		
35	176	217	129	162	139	179		
50	214	265	157	197	169	218		
70	270	336	199	250	213	275		
95	334	415	246	308	264	336		
120	389	485	285	359	307	388		
150	446	557	326	412	352	438		
185	516	647	374	475	406	501		
240	618	775	445	564	483	580		
300	711	894	510	649	552	649		
400	843	1061	597	761	646	734		
500	994	1254	663	860	747	827		
630	1180	1486	-----	-----	858	934		
800	1396	1751	-----	-----	971	-----		
1000	1620	2044	-----	-----	1078	-----		

<sup>1)</sup> Current in DC circuits with return conductor far away.

<sup>2)</sup> For auxiliary and multicore cables with 4-cores fully loaded.

**Basic assumption and conditions of installation:**

Ambient temperature: 30 °C  
 Distance between cables: 2 x overall diameter  
 Loading factor: 1.0  
 Distance between cables and walls, ground or ceiling: 2 cm  
 Distance between systems (one upon another) : 30 cm  
 Distance between cables(side by side): 2 x overall diameter  
 Distance between cables(one upon another): 2 x overall diameter  
 (VDE 0298)

**Table 5: Current Ratings (AC) -  $U_0 / U$  0.6 / 1 kV  
Copper conductors laid direct in ground**

Nominal cross-sectional area	 <sup>1)</sup>		 <sup>2)</sup>			
	nom. (mm <sup>2</sup> )	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)	PVC (A)
1.5	41	48	27	31	30	33
2.5	55	63	36	40	39	42
4	71	82	46	52	50	54
6	90	102	58	64	62	67
10	124	136	78	86	83	89
16	160	176	101	111	107	115
25	208	229	132	145	138	148
35	250	275	159	174	164	177
50	296	326	188	206	195	209
70	365	400	232	254	238	256
95	438	480	280	305	286	307
120	501	548	318	348	325	349
150	563	616	359	392	365	393
185	639	699	406	444	413	445
240	746	815	473	517	479	516
300	845	924	535	585	539	581
400	975	1065	613	671	614	662
500	1125	1228	684	756	693	749
630	1304	1421	-----	-----	777	843
800	1507	1638	-----	-----	859	935
1000	1715	1870	-----	-----	936	1022

<sup>1)</sup> Current in DC circuits with return conductor far away.

<sup>2)</sup> For auxiliary and multicore cables with 4-cores fully loaded.

**Basic assumption and conditions of installation:**

Thermal resistivity of soil: 1.0 Km/W  
 Standard ground temperature: 20 °C  
 Loading factor: 0.7  
 Depth of burial: 0.7 – 1.2 m  
 No. of cable systems: 1  
 (VDE 0298)

**Table 6: Current Ratings (AC) -  $U_0 / U$  0.6 / 1 kV  
Copper conductors laid in single way ducts**

Nominal cross-sectional area  nom. (mm <sup>2</sup> )	 <sup>1)</sup>		 <sup>2)</sup>			
	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)	PVC (A)	XLPE (A)
1.5	35	41	23	26	26	28
2.5	47	54	31	34	33	36
4	60	70	39	44	43	46
6	77	87	49	54	53	57
10	105	116	66	73	71	76
16	136	150	86	94	91	98
25	177	195	112	123	117	126
35	213	234	135	148	139	150
50	252	277	160	175	166	178
70	310	340	197	216	202	218
95	372	408	238	259	243	261
120	426	466	270	296	276	297
150	479	524	305	333	310	334
185	543	594	345	377	351	378
240	634	693	402	439	407	439
300	718	785	455	497	485	494
400	829	905	521	570	522	563
500	956	1044	581	643	589	637
630	1108	1208	-----	-----	660	717
800	1281	1392	-----	-----	730	795
1000	1458	1590	-----	-----	796	869

<sup>1)</sup> Current in DC circuits with return conductor far away.

<sup>2)</sup> For auxiliary and multicore cables with 4-cores fully loaded.

**Basic assumption and conditions of installation:**

Thermal resistivity of soil: 1.0 Km/W  
 Standard ground temperature: 20 °C  
 Loading factor: 0.7  
 Depth of burial: 0.7 – 1.2 m  
 No. of cable systems: 1  
 (VDE 0298)

The term "ducts" means fibre, ferrous or earthenware pipes. In case of single core cables for use in AC-systems, ferrous ducts should not be applied.

## II Tests

**Table 7: Test Requirements**

No.	Tests	Requirements acc. to	Test method acc. to	Scope of test *)
<b>1. Electrical Properties</b>				
1.1	Conductor resistance	IEC 60228	IEC 60502-1	R
1.2	Voltage test	IEC 60502-1	IEC 60502-1	R
1.3	Insulation resistance	IEC 60502-1	IEC 60502-1	T
1.4	Voltage test for 4 h	IEC 60502-1	IEC 60502-1	T
<b>2. Dimensions</b>				
2.1	Conductor examination	IEC 60228	IEC 60502-1	S
2.2	Measurement of thickness of insulation and of non-metallic sheath (excluding inner extruded coverings).	IEC 60502-1	IEC 60811-1-1	S
2.3	Measurement of armour wires and tapes	IEC 60502-1	IEC 60502-1	S
2.4	Measurement of external diameter	---	IEC 60811-1-1	S
<b>3. Mechanical Properties and Thermal Behaviour</b>				
3.1	Hot set test for XLPE insulations and elastomeric sheaths.	IEC 60502-1	IEC 60811-2-1	S
3.2	Mechanical and thermal properties of insulations and sheaths.	IEC 60502-1	IEC 60811	T
<b>4. Cable</b>				
4.1	Flame Retardancy**)	IEC 60332-1	IEC 60332-1	T
4.2	Flame Propagation**)	IEC 60332-3	IEC 60332-3	T
4.3	Fire Resistance**)	IEC 60331-21	IEC 60331-21	T
4.4	Smoke Density**)	IEC 61034-1 and 2	IEC 61034-1 and 2	T
4.5	Amount of halogen gas acid**)	data sheet	IEC 60754-1	T
4.6	Degree of acidity of gases**)	IEC 60754-2	IEC 60754-2	T
4.7	Limiting Oxygen Index (LOI)**) (only for outer sheath material)	data sheet	IEC 60332-3 ann. B	T
4.8	Temperature Index (TI)**) (only for outer sheath material)	data sheet	ASTM-D-2863	T

\*) **Routine tests (R)**

Tests made by the manufacturer on each manufactured length of cable to check that each length meets the specified requirements.

\*) **Sample tests (S)**

Tests made by the manufacturer on samples or completed cable or components taken from a completed cable, at a specified frequency, so as to verify that the finished product meets the specified requirements.

\*) **Type tests (T)**

Tests made before supplying, on a general commercial basis, a type of cable covered by this standard, in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not to be repeated, unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

\*\*\*) Tests are not applicable to all cable types.

III General Information

Table 8: Conductor Comparisons AWG - Metric

Comparison of plain annealed copper conductors acc. to ICEA S-61-402 and IEC 60228

Conductor Size		No. of wires <sup>2)</sup>	Electrical Resistance <sup>3)</sup>	
AWG or kcmil	Metric <sup>1)</sup> (mm <sup>2</sup> )		IEC <sup>4)</sup> (Ω/km)	ICEA <sup>5)</sup> (Ω/km)
16	1.31	7	-	13.98
-	<b>1.5</b>	<b>7</b>	<b>12.1</b>	-
15	1.65	7	-	11.04
14	2.08	7	-	8.80
-	<b>2.5</b>	<b>7</b>	<b>7.41</b>	-
13	2.63	7	-	6.96
12	3.31	7	-	5.55
-	<b>4</b>	<b>7</b>	<b>4.61</b>	-
11	4.17	7	-	4.38
10	5.261	7	-	3.48
-	<b>6</b>	<b>7</b>	<b>3.08</b>	-
9	6.631	7	-	2.760
8	8.367	7	-	2.181
-	<b>10</b>	<b>7</b>	<b>1.83</b>	-
7	10.55	7	-	1.736
6	13.30	7	-	1.375
-	<b>16</b>	<b>7</b>	<b>1.15</b>	-
5	16.77	7	-	1.087
4	21.15	7	-	0.863
-	<b>25</b>	<b>7</b>	<b>0.727</b>	-
3	26.67	7	-	0.686
2	33.62	7	-	0.542
-	<b>35</b>	<b>7</b>	<b>0.524</b>	-
1	42.41	19	-	0.432
-	<b>50</b>	<b>19</b>	<b>0.387</b>	-
1/0	53.49	19	-	0.341
2/0	67.43	19	-	0.2710
-	<b>70</b>	<b>19</b>	<b>0.268</b>	-
3/0	85.01	19	-	0.2148
-	<b>95</b>	<b>19</b>	<b>0.193</b>	-
4/0	107.2	19	-	0.1706
-	<b>120</b>	<b>37</b>	<b>0.153</b>	-
250	127	37	-	0.1442
-	<b>150</b>	<b>37</b>	<b>0.124</b>	-
300	152	37	-	0.1204
350	177	37	-	0.1030
-	<b>185</b>	<b>37</b>	<b>0.0991</b>	-
400	203	37	-	0.0900
450	228	37	-	0.0803
-	<b>240</b>	<b>61</b>	<b>0.0754</b>	-
500	253	37	-	0.0723
550	279	61	-	0.0656
-	<b>300</b>	<b>61</b>	<b>0.0601</b>	-
600	304	61	-	0.0602
650	329	61	-	0.0555
700	355	61	-	0.0515
750	380	61	-	0.0482
-	<b>400</b>	<b>61</b>	<b>0.0470</b>	-
800	405	61	-	0.0452
900	456	61	-	0.0401
-	<b>500</b>	<b>61</b>	<b>0.0366</b>	-
1000	507	61	-	0.0361
1100	557	91	-	0.0328
1200	608	91	-	0.0301
-	<b>630</b>	<b>91</b>	<b>0.0283</b>	-
1250	633	91	-	0.0289
1300	659	91	-	0.0278
1400	709	91	-	0.0258
1500	760	91	-	0.0241
-	<b>800</b>	<b>91</b>	<b>0.0221</b>	-
1600	811	127	-	0.0225
1700	861	127	-	0.0212
1750	887	127	-	0.0206
1800	912	127	-	0.0200
1900	963	127	-	0.0190
-	<b>1000</b>	<b>91</b>	<b>0.0176</b>	-

1) Sizes acc. to IEC 60228 printed in bold letters  
 2) Minimum numbers of wires for the corresponding cross-section acc. to IEC 60228  
 3) The value for the electrical resistance is given for 20 °C (68.0 °F)  
 4) The value for the electrical resistance acc. to IEC is for the finished cable and cores in layers  
 5) The value for the electrical resistance acc. to ICEA S-61-402 is calculated for "one layer of conductors"



**Table 9: Cable Abbreviations**

Abbreviations used by KERPEN for power and control cables	
Y	Insulation or sheath of polyvinyl chloride PVC
2X	Insulation of cross-linked polyethylene XLPE
H	Sheath of zero halogen flame retardant compound LSZH(Low Smoke Zero Halogen)
R	Armour of galvanized round steel wires
B	Armour of galvanized steel tapes - double layer
Q	Armour of galvanized steel wire braid
K	Lead sheath
-fl	Cable with reduced flame propagation

## CABLE PROGRAMME

- ◆ INSTRUMENTATION AND CONTROL CABLES



- ◆ THERMOCOUPLE EXTENSION AND COMPENSATING CABLES



- ◆ POWER CABLES  
(LOW AND MEDIUM VOLTAGE)



- ◆ TELECOMMUNICATION CABLES



- ◆ DATA AND BUS CABLES  
COPPER AND FIBRE OPTIC



- ◆ MINING CABLES



- ◆ CABLES FOR SPECIAL APPLICATIONS



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