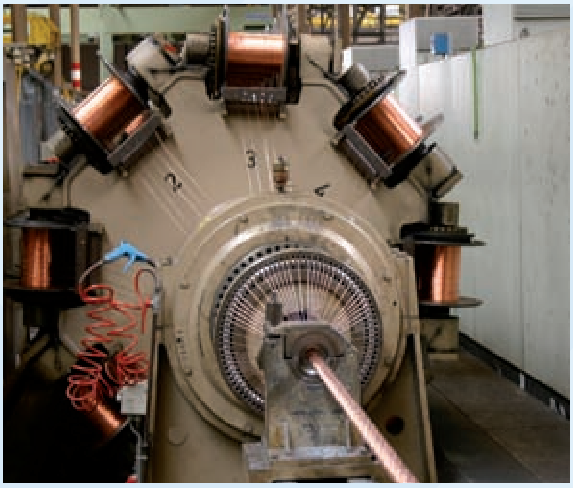
PRYSMIAN
CABLES & SYSTEMS

High Voltage Cables



The history of cables

Since its establishment in 1913, Prysmian Cables and Systems B.V. has developed into a leading global manufacturer of cable systems. Prysmian Cables and Systems B.V. has pioneered and patented the development of extruded cable systems, such as the prefabricated stress cone (1964), the prefabricated joint body (1965), the in-line cross-linking of extruded cables (1970) and the click-fit range of accessories (1990).

Today

Prysmian Cables and Systems B.V. is part of the Prysmian Group, a leading player in the industry of high-technology cables and systems for energy and telecommunications, with more than 50 production plants in 21 countries worldwide. In addition, the Group has a worldwide network of sales and representative offices.

Prysmian Cables and Systems B.V. is based in Delft, the Netherlands. We produce energy cables ranging from low voltage (1kV) to high voltage (500kV) for land and submarine application, along with compatible Click-Fit® accessories. All our products are tailored to meet the customer's requirements.

Our company has been at the cutting edge of high voltage cable technology for several decades. We have experience in supplying all types of high voltage cable systems throughout the world, based on a full turnkey engineering service and installation capability. Our extended after sales services is second to none, with 24/7 Emergency and Condition-Based Maintenance, on-site Fault Location, Diagnostics and Assessments, Material Qualification and Testing in our HV Laboratory.

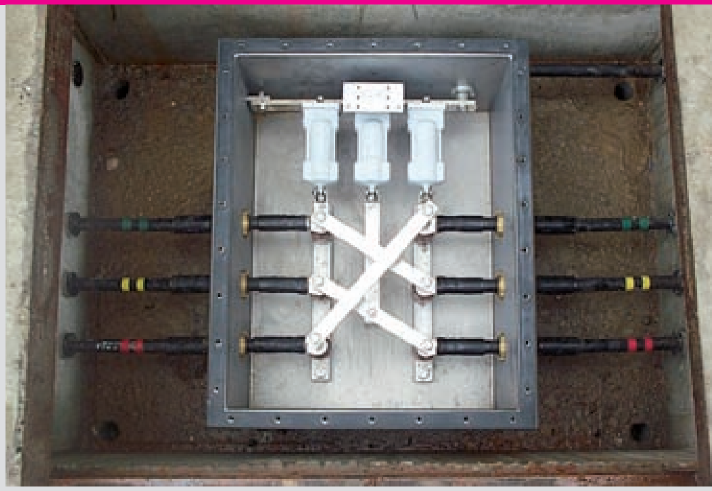
Environmental and reliability aspects

When planning a new supply route, environmental factors have to be taken into account due to mandatory regulations and public opinion.

The XLPE cables are environmentally-friendly and safe due to XLPE's insolubility in water and its inert, halogen-free chemical structure.

The cable system is out of sight and the cable route limited compared with overhead lines. Once installed, the site generally can revert to its originally intended purpose, thus resulting in considerable savings.
Reducing the electrical and magnetic fields is also becoming more important. The cable system can be designed based on a range of magnetic field requirements, with zero external electrical fields. Cable systems offer better safety for personnel and public alike, with fewer danger situations owing to accidental contact or flashovers.

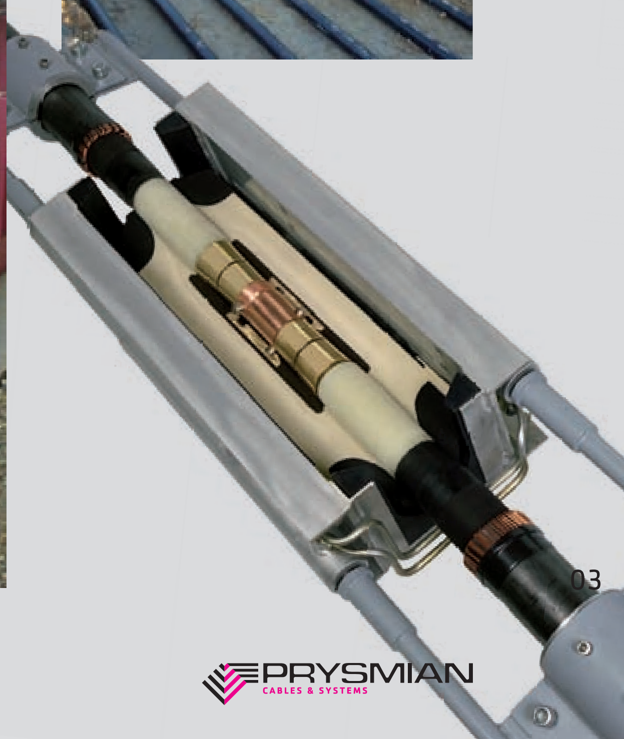
Network reliability is all important because loss of power has high cost consequences. Cable systems are less vulnerable to failure compared with overhead lines.



Prysmian sets high standards

Our high standards are certified according to the ISO 9001:2000 Quality Management and ISO 14001 Environmental Management System Standard.

The production, testing and installation of cable systems is subject to standards agreed between the customer and Prysmian Cables and Systems B.V.. These range from the generally accepted standards, such as IEC and AEIC, to the customer's specific requirements or standards that apply locally.



High Voltage XLPE cable production

Since the introduction of polymeric insulation, we have made an important contribution to the development of extruded dielectric cables.

Intensive research on materials, together with the processing and investment in advanced extrusion machinery, led to the commercial use of the long land die dry-curing process for the manufacture of high voltage and extra high voltage cables, which meet the highest quality standards. In a triple extrusion process, the semi-conductive conductor screen, the insulation and the insulation screen are applied simultaneously. The temperature of the materials leaving the extrusion head is relatively low so as to prevent premature cross-linking. Cross-linking proper takes place at a high temperature and high pressure in the electrically heated long die, where the materials are heated to the temperature required to activate the chemical reaction effectuating the cross-linking. Gradual cooling at high pressure after cross-linking prevents the formation of voids and the creation of internal mechanical stresses.

Cable finishing

Prysmian Cables and Systems B.V. offer a variety of cable finishing:
- lead alloy sheath;
- welded aluminium sheath;
- copper wire screen.

In addition, Prysmian Cables and Systems B.V. can produce the following optional finishing:
- lead alloy sheath with copper wire screen;
- welded aluminium sheath with copper wire screen;
- copper wire screen with aluminium laminated foil or copper foil;
- integrated optical fibres for distributed temperature measurements;
- aluminium wires or steel armouring;
- LSOH outer sheath;
- extruded semi-conductive layer on outer sheath.

Prysmian Cables and Systems B.V. have the capability of handling 80 tons maximum gross weight of delivery drums. This allows for the production of very long (E)HV cable lengths of up to 3.2 km. Specific cable constructions and test regimes can be offered on request.

Item	Sample A	Sample B	Sample C
Cable type	EYLKrvlwd	YMeKrvasdlwd	EYAKrvlwd
1	**Conductor** Longitudinal watertight solid aluminium rod	**Conductor** Longitudinal watertight stranded and compacted copper, including binder tape	**Conductor** Longitudinal watertight segmental stranded and compacted copper, including binder tape
2	**Conductor screen** Extruded semiconducting copolymer compound	**Conductor screen** Extruded semiconducting copolymer compound	**Conductor screen** Extruded semiconducting copolymer compound
3	**Insulation** Extruded XLPE	**Insulation** Extruded XLPE	**Insulation** Extruded XLPE
4	**Insulation screen** Extruded semiconducting copolymer compound	**Insulation screen** Extruded semiconducting copolymer compound	**Insulation screen** Extruded semiconducting copolymer compound
5	**Bedding** Semiconducting water blocking tapes	**Bedding** Semiconducting water blocking tapes	**Bedding** Semiconducting water blocking tapes
6	**Metallic sheath** Extruded lead alloy	**Metallic screen** A layer of copper wire helix and a copper contact tape counter helix	**Metallic sheath** Aluminium welded sheath
7	**Outer sheath** Extruded PE	**Separation tape** Semiconducting water blocking and binder tapes	**Outer sheath** Extruded PE
8		**Radial water barrier** Aluminium foil laminate	
9		**Outer sheath** Extruded PE	

Sample constructions

Rated voltages:
U_o/U = 36/66 kV
U_m = 72.5 kV
U_p = 350 kV

72kV cables 36/66kV Single core, XLPE insulated high voltage power cables

Constructional data

Nominal cross-sectional area of conductor		unit	240	400	630	800	1000	1200	1600	2000
Outer diameter	With aluminium conductor	mm	63	66	72	73	77	77	96	103
	With copper conductor	mm	64	71	76	78	88	91	96	103
Net weight with Pb sheath	With aluminium conductor	kg/m	9.9	10.5	11.5	11.9	12.7	13.0	15.5	16.5
	With copper conductor	kg/m	11.5	13.2	15.9	17.3	21.1	22.1	26.4	29.6
Minimum bending radius during cable laying		m	1.6	1.8	1.9	2.0	2.2	2.3	2.4	2.6

Electrical properties at 66kV and 50 Hz

				unit	240	400	630	800	1000	1200	1600	2000
Aluminium conductor	Max. DC-resistance	at 20°C		Ω/km	0.1250	0.0778	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149
	AC resistance	at 90°C, approx.		Ω/km	0.161	0.101	0.062	0.050	0.041	0.036	0.025	0.198
Copper conductor	Max. DC-resistance	at 20°C		Ω/km	0.0754	0.0470	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090
	AC resistance	at 90°C, approx.		Ω/km	0.097	0.062	0.040	0.033	0.024	0.021	0.017	0.014
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345
Reactance (approx.)	Metallic sheath closed	Trefoil	touching	Ω/km	0.140	0.127	0.118	0.113	0.109	0.106	0.104	0.097
		Flat	0.15m	Ω/km	0.207	0.192	0.176	0.168	0.160	0.155	0.135	0.132
		Flat	0.30m	Ω/km	0.247	0.232	0.214	0.206	0.197	0.191	0.165	0.162
	Metallic sheath open	Flat	0.15m	Ω/km	0.210	0.195	0.179	0.172	0.164	0.159	0.141	0.136
		Flat	0.30m	Ω/km	0.254	0.239	0.223	0.215	0.208	0.203	0.185	0.179
		Flat	0.45m	Ω/km	0.279	0.264	0.248	0.241	0.233	0.228	0.210	0.205
Operating capacitance				µF/km	0.18	0.20	0.24	0.29	0.31	0.35	0.37	0.41
Charging current				A/km	2.6	2.3	2.7	3.3	3.5	4.0	4.2	4.6

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing	unit	240	400	630	800	1000	1200	1600	2000
Aluminium	In ground	Closed	Trefoil	touching	A	380	488	630	708	783	835	1013	1104
			Flat	0.15m	A	388	490	609	672	728	764	893	959
		Open	Flat	0.15m	A	405	525	684	775	867	934	1139	1255
			Flat	0.45m	A	444	578	760	865	974	1055	1300	1453
	In buried ducts	Closed	Flat	0.30m	A	374	465	562	611	650	673	776	827
		Open	Flat	0.30m	A	403	522	685	778	875	947	1149	1301
	In air	Closed	Trefoil	touching	A	486	644	863	988	1116	1208	1550	1717
		Closed	Flat	0.15m	A	534	706	931	1060	1188	1278	1263	1384
		Open	Flat	0.15m	A	548	737	1005	1164	1335	1463	1657	1869
Copper	In ground	Closed	Trefoil	touching	A	489	622	781	865	969	1036	1117	1239
			Flat	0.15m	A	490	604	730	786	843	895	929	1037
		Open	Flat	0.15m	A	525	675	868	972	1130	1210	1369	1508
			Flat	0.45m	A	577	748	971	1096	1282	1385	1567	1782
	In buried ducts	Closed	Flat	0.30m	A	465	559	654	691	751	790	806	892
		Open	Flat	0.30m	A	523	675	874	984	1163	1251	1402	1563
	In air	Closed	Trefoil	touching	A	633	832	1090	1229	1435	1558	1673	1960
		Closed	Flat	0.15m	A	791	936	1088	1155	1361	1406	1482	1534
		Open	Flat	0.15m	A	719	963	1295	1591	1842	1976	2433	2674

Maximum permissible short-circuit currents for short circuit duration of one second

	unit	240	400	630	800	1000	1200	1600	2000
Aluminium conductor	kA	23.1	38.4	60.3	76.5	95.5	114.5	152.5	190.4
Copper conductor	kA	34.9	57.9	91.0	115.5	144.2	172.9	230.3	287.7
Metallic sheath	kA	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3

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Sample constructions

Rated voltages:
U_o/U = 64/110 kV
U_m = 123 kV
U_p = 550 kV

123kV cables 64/110kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor		mm^2	400	630	800	1000	1200	1600	2000	2500

Constructional data

			400	630	800	1000	1200	1600	2000	2500
Outer diameter	With aluminium conductor	mm	66	72	74	78	81	101	111	111
	With copper conductor	mm	73	76	83	87	92	99	112	112
Net weight	With aluminium conductor	kg/m	10.5	11.5	11.9	12.7	13.5	19.1	19.6	21.7
with Pb sheath	With copper conductor	kg/m	13.6	15.9	18.5	21.5	23.0	27.8	32.5	42.5
Minimum bending radius during cable laying		m	1.8	1.9	2.1	2.2	2.3	2.5	2.8	2.8

Electrical properties at 110kV and 50 Hz

					400	630	800	1000	1200	1600	2000	2500
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0778	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.101	0.062	0.050	0.041	0.036	0.024	0.020	0.017
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0754	0.0470	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090
conductor	AC resistance	at 90°C, approx.		Ω/km	0.062	0.040	0.033	0.024	0.021	0.017	0.014	0.012
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.327	0.327	0.327	0.327	0.327	0.327	0.327	0.327
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.138	0.124	0.120	0.115	0.112	0.104	0.102	0.096
(approx.)		Flat	0.15m	Ω/km	0.191	0.175	0.167	0.159	0.154	0.135	0.131	0.125
		Flat	0.30m	Ω/km	0.228	0.212	0.203	0.194	0.189	0.165	0.164	0.158
	Metallic sheath open	Flat	0.15m	Ω/km	0.195	0.179	0.172	0.164	0.159	0.141	0.135	0.130
		Flat	0.30m	Ω/km	0.239	0.223	0.215	0.208	0.203	0.185	0.179	0.173
		Flat	0.45m	Ω/km	0.264	0.248	0.241	0.233	0.228	0.210	0.204	0.199
Operating capacitance				μF/km	0.17	0.23	0.23	0.27	0.28	0.30	0.29	0.36
Charging current				A/km	3.4	4.6	4.6	5.4	5.6	6.0	5.8	7.2

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		400	630	800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	486	628	728	778	831	1013	1096	1169
			Flat	0.15m	A	480	602	661	717	757	893	942	988
		Open	Flat	0.15m	A	515	675	763	853	919	1114	1223	1323
			Flat	0.45m	A	567	749	852	960	1040	1277	1433	1575
	In buried ducts	Closed	Flat	0.30m	A	454	555	599	637	665	784	807	835
		Open	Flat	0.30m	A	516	679	771	866	937	1146	1283	1403
	In air	Closed	Trefoil	touching	A	638	856	979	1105	1197	1530	1696	1860
		Closed	Flat	0.15m	A	688	917	1042	1168	1262	1440	1530	1641
		Open	Flat	0.15m	A	716	982	1137	1301	1424	1884	2095	2366
Copper	In ground	Closed	Trefoil	touching	A	619	779	861	955	998	1066	1210	1277
			Flat	0.15m	A	593	718	779	831	856	892	1001	1037
		Open	Flat	0.15m	A	663	857	958	1097	1166	1288	1460	1579
			Flat	0.45m	A	733	957	1080	1246	1341	1523	1754	1941
	In buried ducts	Closed	Flat	0.30m	A	548	640	682	712	723	737	860	885
		Open	Flat	0.30m	A	666	866	974	1129	1212	1369	1564	1719
	In air	Closed	Trefoil	touching	A	823	1080	1220	1402	1499	1663	1917	2078
		Closed	Flat	0.15m	A	877	1136	1276	1438	1528	1605	1700	1777
		Open	Flat	0.15m	A	934	1265	1452	1709	1860	2146	2543	2877

Maximum permissible short-circuit currents for short circuit duration of one second

		400	630	800	1000	1200	1600	2000	2500
Aluminium conductor	kA	38.4	60.3	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	57.9	91.0	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1

Sample constructions

Rated voltages:
U_0/U = 76/132 kV
U_m = 145 kV
U_p = 650 kV

145kV cables 76/132kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor		mm²	400	630	800	1000	1200	1600	2000	2500

Constructional data

			400	630	800	1000	1200	1600	2000	2500
Outer diameter	With aluminium conductor	mm	77	81	81	84	89	105	112	117
	With copper conductor	mm	77	84	89	99	100	105	112	117
Net weight	With aluminium conductor	kg/m	11.4	12.6	13.5	15.9	16.0	17.1	17.9	20.9
with Pb sheath	With copper conductor	kg/m	14.0	16.8	18.8	22.5	23.2	27.7	31.1	37.4
Minimum bending radius during cable laying		m	1.9	2.0	2.2	2.3	2.5	2.6	2.8	2.9

Electrical properties at 132kV and 50 Hz

					400	630	800	1000	1200	1600	2000	2500
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0778	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.101	0.062	0.050	0.041	0.036	0.024	0.020	0.017
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0470	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.062	0.039	0.032	0.024	0.021	0.017	0.014	0.012
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.340	0.343	0.337	0.348	0.347	0.343	0.335	0.319
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.142	0.128	0.123	0.118	0.115	0.106	0.102	0.099
(approx.)		Flat	0.15m	Ω/km	0.190	0.175	0.167	0.159	0.154	0.135	0.133	0.127
		Flat	0.30m	Ω/km	0.226	0.211	0.202	0.194	0.188	0.164	0.169	0.163
	Metallic sheath open	Flat	0.15m	Ω/km	0.195	0.179	0.172	0.164	0.159	0.141	0.136	0.130
		Flat	0.30m	Ω/km	0.239	0.223	0.215	0.208	0.203	0.185	0.179	0.173
		Flat	0.45m	Ω/km	0.264	0.248	0.241	0.233	0.228	0.210	0.205	0.199
Operating capacitance				µF/km	0.16	0.19	0.21	0.22	0.24	0.27	0.29	0.32
Charging current				A/km	3.8	4.5	5.0	5.3	5.7	6.4	6.9	7.6

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		400	630	800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	485	626	702	777	828	1051	1162	1237
			Flat	0.15m	A	477	598	657	716	752	933	1017	1072
		Open	Flat	0.15m	A	512	670	758	848	912	1148	1275	1365
			Flat	0.45m	A	564	744	847	954	1034	1317	1486	1615
	In buried ducts	Closed	Flat	0.30m	A	451	538	594	636	659	820	880	915
		Open	Flat	0.30m	A	514	649	767	862	932	1183	1330	1442
	In air	Closed	Trefoil	touching	A	636	852	974	1100	1190	1521	1722	1870
		Closed	Flat	0.15m	A	683	910	1033	1163	1253	1432	1595	1688
		Open	Flat	0.15m	A	710	972	1124	1286	1407	1835	2095	2342
Copper	In ground	Closed	Trefoil	touching	A	617	778	858	947	990	1061	1299	1375
			Flat	0.15m	A	590	717	774	824	850	892	1095	1140
		Open	Flat	0.15m	A	659	851	951	1087	1154	1275	1528	1644
			Flat	0.45m	A	728	951	1073	1239	1332	1513	1819	2005
	In buried ducts	Closed	Flat	0.30m	A	543	639	676	706	718	738	946	980
		Open	Flat	0.30m	A	663	861	969	1122	1204	1358	1623	1781
	In air	Closed	Trefoil	touching	A	820	1076	1214	1390	1485	1657	1966	2130
		Closed	Flat	0.15m	A	871	1131	1268	1429	1520	1686	1763	1857
		Open	Flat	0.15m	A	927	1251	1435	1688	1835	2115	2546	2850

Maximum permissible short-circuit currents for short circuit duration of one second

		400	630	800	1000	1200	1600	2000	2500
Aluminium conductor	kA	38.4	60.3	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	57.9	91.0	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	17.3	17.4	17.7	17.5	17.5	17.8	18.3	19.2

Sample constructions

Rated voltages:
U_o/U = 87/150 kV
U_m = 170 kV
U_p = 750 kV

170kV cables 87/150kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor		mm^2	400	630	800	1000	1200	1600	2000	2500

Constructional data

			400	630	800	1000	1200	1600	2000	2500
Outer diameter	With aluminium conductor	mm	80	90	91	91	95	113	114	120
	With copper conductor	mm	86	89	93	103	103	109	116	120
Net weight	With aluminium conductor	kg/m	12.7	13.8	14.1	14.3	15.3	20.2	25.3	31.4
with Pb sheath	With copper conductor	kg/m	17.3	19.4	21.5	25.2	25.9	30.5	33.8	39.8
Minimum bending radius during cable laying		m	2.1	2.2	2.3	2.6	2.6	2.8	2.9	3.0

Electrical properties at 150kV and 50 Hz

					400	630	800	1000	1200	1600	2000	2500
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0778	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.101	0.062	0.050	0.041	0.035	0.024	0.020	0.017
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0470	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.062	0.039	0.032	0.024	0.021	0.017	0.014	0.012
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.263	0.262	0.255	0.262	0.261	0.255	0.256	0.254
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.143	0.132	0.126	0.121	0.118	0.109	0.104	0.100
(approx.)		Flat	0.15m	Ω/km	0.185	0.174	0.166	0.159	0.154	0.135	0.131	0.125
		Flat	0.30m	Ω/km	0.219	0.209	0.200	0.192	0.186	0.163	0.160	0.158
	Metallic sheath open	Flat	0.15m	Ω/km	0.190	0.179	0.172	0.164	0.159	0.141	0.136	0.130
		Flat	0.30m	Ω/km	0.234	0.223	0.215	0.208	0.203	0.185	0.179	0.173
		Flat	0.45m	Ω/km	0.259	0.248	0.241	0.233	0.228	0.210	0.205	0.199
Operating capacitance				μF/km	0.15	0.19	0.21	0.22	0.24	0.27	0.29	0.32
Charging current				A/km	4.1	5.2	5.7	6.0	6.6	7.4	7.9	8.7

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		400	630	800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	482	625	700	775	826	978	1077	1152
			Flat	0.15m	A	477	594	653	712	748	858	931	987
		Open	Flat	0.15m	A	512	665	753	842	905	1084	1211	1300
			Flat	0.45m	A	564	738	842	948	1028	1256	1424	1557
	In buried ducts	Closed	Flat	0.30m	A	451	545	589	631	654	744	795	883
		Open	Flat	0.30m	A	515	671	763	857	927	1129	1274	1387
	In air	Closed	Trefoil	touching	A	643	846	969	1094	1184	1477	1673	1829
		Closed	Flat	0.15m	A	689	901	1026	1155	1245	1358	1430	103
		Open	Flat	0.15m	A	714	957	1112	1271	1390	1784	2084	2313
Copper	In ground	Closed	Trefoil	touching	A	608	774	855	940	981	1051	1187	1258
			Flat	0.15m	A	586	709	769	819	844	887	985	1029
		Open	Flat	0.15m	A	654	842	944	1077	1142	1259	1445	1548
			Flat	0.45m	A	722	943	1067	1231	1324	1503	1742	1917
	In buried ducts	Closed	Flat	0.30m	A	539	629	670	700	713	733	847	882
		Open	Flat	0.30m	A	659	855	964	1116	1196	1349	1552	1698
	In air	Closed	Trefoil	touching	A	815	1068	1207	1379	1475	1641	1888	2049
		Closed	Flat	0.15m	A	863	1119	1260	1421	1512	1679	1710	1738
		Open	Flat	0.15m	A	913	1231	1418	1667	1811	2085	2520	2819

Maximum permissible short-circuit currents for short circuit duration of one second

		400	630	800	1000	1200	1600	2000	2500
Aluminium conductor	kA	38.4	60.3	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	57.9	91.0	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	24.9	24.5	24.9	24.1	24.2	24.7	24.6	24.7

Sample constructions

Rated voltages:
U_0/U = 127/220 kV
U_m = 245 kV
U_p = 1050 kV

245kV cables 127/220kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor					mm²	630	800	1000	1200	1600	2000	2500
Constructional data												
Outer diameter	With aluminium conductor				mm	107	107	108	111	123	126	130
	With copper conductor				mm	103	103	110	111	118	127	134
Net weight	With aluminium conductor				kg/m	18.9	19.8	21.3	22.8	25.7	27.9	31.5
with Pb sheath	With copper conductor				kg/m	23.1	25.1	27.9	30.7	36.6	41.1	48.0
Minimum bending radius during cable laying					m	2.7	2.7	2.7	2.8	3.1	3.2	3.4
Electrical properties at 220kV and 50 Hz												
Aluminium	Max. DC-resistance	at 20°C			Ω/km	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.			Ω/km	0.062	0.049	0.040	0.035	0.0242	0.0197	0.0169
Copper	Max. DC-resistance	at 20°C			Ω/km	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.			Ω/km	0.039	0.032	0.024	0.021	0.017	0.0134	0.0115
DC-resistance of metallic sheath at 20°C approx.					Ω/km	0.274	0.273	0.277	0.276	0.275	0.270	0.270
Reactance	Metallic sheath closed	Trefoil	touching		Ω/km	0.136	0.136	0.130	0.125	0.113	0.106	0.103
(approx.)		Flat	0.15m		Ω/km	0.166	0.165	0.158	0.152	0.134	0.131	0.125
		Flat	0.30m		Ω/km	0.195	0.194	0.187	0.181	0.160	0.158	0.156
	Metallic sheath open	Flat	0.15m		Ω/km	0.173	0.172	0.165	0.159	0.141	0.136	0.130
		Flat	0.30m		Ω/km	0.216	0.215	0.208	0.203	0.185	0.179	0.173
		Flat	0.45m		Ω/km	0.242	0.241	0.234	0.228	0.210	0.205	0.199
Operating capacitance					µF/km	0.14	0.16	0.18	0.19	0.22	0.23	0.27
Charging current					A/km	5.6	6.4	7.2	7.6	8.8	9.2	10.8
Continuous current-carrying capacities												
Conductor	Cables laid	Sheath circuit	Laying formation	Spacing								
Aluminium	In ground	Closed	Trefoil	touching	A	622	691	764	813	973	1074	1146
			Flat	0.15m	A	587	642	699	735	855	929	985
		Open	Flat	0.15m	A	655	732	818	880	1068	1186	1266
			Flat	0.45m	A	732	823	928	1008	1245	1407	1532
	In buried ducts	Closed	Flat	0.30m	A	537	578	618	642	742	793	820
		Open	Flat	0.30m	A	669	751	845	915	117	1256	1362
	In air	Closed	Trefoil	touching	A	850	948	1072	1162	1472	1671	1815
		Closed	Flat	0.15m	A	903	1001	1129	1221	1351	1507	1587
		Open	Flat	0.15m	A	952	1068	1223	1341	1707	2048	2263
Copper	In ground	Closed	Trefoil	touching	A	765	843	921	960	1025	1181	1248
			Flat	0.15m	A	699	757	807	831	871	976	1017
		Open	Flat	0.15m	A	822	918	1050	1109	1216	1410	1501
			Flat	0.45m	A	927	1048	1212	1301	1478	1720	1886
	In buried ducts	Closed	Flat	0.30m	A	617	657	690	703	723	845	880
		Open	Flat	0.30m	A	846	952	1097	1175	1324	1529	1665
	In air	Closed	Trefoil	touching	A	1056	1191	1355	1445	1610	1889	2038
		Closed	Flat	0.15m	A	1106	1245	1404	1495	1662	1651	1727
		Open	Flat	0.15m	A	1200	1375	1619	1755	2020	2486	2763
Maximum permissible short-circuit currents for short circuit duration of one second												
Aluminium conductor					kA	60.3	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor					kA	91.0	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath					kA	21.9	21.9	21.9	21.9	21.9	21.9	21.9

PRYSMIAN CABLES & SYSTEMS

Sample constructions

Rated voltages:
U_o/U = 160/275 kV
U_m = 300 kV
U_p = 1050 kV

300kV cables 160/275kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor		mm²	630	800	1000	1200	1600	2000	2500

Constructional data

			630	800	1000	1200	1600	2000	2500
Outer diameter	With aluminium conductor	mm	107	107	108	111	123	126	130
	With copper conductor	mm	103	103	110	111	118	127	134
Net weight	With aluminium conductor	kg/m	18.9	19.8	21.3	22.8	25.7	27.9	31.5
with Pb sheath	With copper conductor	kg/m	23.1	25.1	27.9	30.7	36.6	41.1	48.0
Minimum bending radius during cable laying		m	2.7	2.7	2.7	2.8	3.1	3.2	3.4

Electrical properties at 220kV and 50 Hz

					630	800	1000	1200	1600	2000	2500
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0469	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.062	0.049	0.040	0.035	0.0242	0.0197	0.0169
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0283	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.039	0.032	0.024	0.021	0.017	0.0134	0.0115
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.274	0.273	0.277	0.276	0.275	0.270	0.270
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.136	0.136	0.130	0.125	0.113	0.106	0.103
(approx.)		Flat	0.15m	Ω/km	0.166	0.165	0.158	0.152	0.134	0.131	0.125
		Flat	0.30m	Ω/km	0.195	0.194	0.187	0.181	0.160	0.158	0.156
	Metallic sheath open	Flat	0.15m	Ω/km	0.173	0.172	0.165	0.159	0.141	0.136	0.130
		Flat	0.30m	Ω/km	0.216	0.215	0.208	0.203	0.185	0.179	0.173
		Flat	0.45m	Ω/km	0.242	0.241	0.234	0.228	0.210	0.205	0.199
Operating capacitance				μF/km	0.14	0.16	0.18	0.19	0.22	0.23	0.27
Charging current				A/km	7.1	8.1	9.1	9.6	11.1	11.6	13.6

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		630	800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	615	684	756	805	964	1064	1135
			Flat	0.15m	A	581	636	692	726	847	920	976
		Open	Flat	0.15m	A	648	725	812	872	1058	1175	1254
			Flat	0.45m	A	725	815	921	998	1233	1394	1516
	In buried ducts	Closed	Flat	0.30m	A	532	572	612	636	735	786	812
		Open	Flat	0.30m	A	662	743	837	906	1007	1214	1349
	In air	Closed	Trefoil	touching	A	846	945	1070	1150	1462	1661	1804
		Closed	Flat	0.15m	A	900	998	1126	1209	1348	1501	1584
		Open	Flat	0.15m	A	949	1065	1219	1328	1701	2040	2258
Copper	In ground	Closed	Trefoil	touching	A	757	835	912	951	1015	1170	1236
			Flat	0.15m	A	692	749	799	823	863	967	1006
		Open	Flat	0.15m	A	814	909	1040	1098	1204	1396	1485
			Flat	0.45m	A	918	1045	1199	1287	1464	1703	1868
	In buried ducts	Closed	Flat	0.30m	A	611	650	683	696	718	837	872
		Open	Flat	0.30m	A	840	942	1086	1164	1311	1514	1649
	In air	Closed	Trefoil	touching	A	1053	1188	1350	1441	1602	1880	2032
		Closed	Flat	0.15m	A	1103	1241	1399	1490	1652	1645	1723
		Open	Flat	0.15m	A	1196	1370	1614	1748	2009	2478	2755

Maximum permissible short-circuit currents for short circuit duration of one second

		630	800	1000	1200	1600	2000	2500
Aluminium conductor	kA	60.3	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	91.0	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	21.9	21.9	21.9	21.9	21.9	21.9	21.9

Sample constructions

Rated voltages:
U_o/U = 200/345 kV
U_m = 362 kV
U_p = 1175 kV

362kV cables 200/345kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor		mm²	800	1000	1200	1600	2000	2500

Constructional data

			800	1000	1200	1600	2000	2500
Outer diameter	With aluminium conductor	mm	110	114	117	129	134	139
	With copper conductor	mm	114	120	125	130	135	139
Net weight	With aluminium conductor	kg/m	22.6	24.7	26.1	27.4	28.4	30.2
with Pb sheath	With copper conductor	kg/m	27.9	31.3	32.1	36.5	40.9	46.4
Minimum bending radius during cable laying		m	2.9	3.0	3.2	3.3	3.4	3.5

Electrical properties at 220kV and 50 Hz

					800	1000	1200	1600	2000	2500
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0493	0.0403	0.0352	0.0242	0.0196	0.0168
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0317	0.0233	0.0203	0.0158	0.0133	0.0113
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.185	0.188	0.188	0.184	0.185	0.187
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.133	0.126	0.121	0.117	0.112	0.108
(approx.)		Flat	0.15m	Ω/km	0.159	0.148	0.144	0.136	0.130	0.124
		Flat	0.30m	Ω/km	0.187	0.174	0.170	0.163	0.157	0.151
	Metallic sheath open	Flat	0.15m	Ω/km	0.167	0.157	0.152	0.143	0.136	0.130
		Flat	0.30m	Ω/km	0.210	0.200	0.196	0.187	0.179	0.173
		Flat	0.45m	Ω/km	0.236	0.226	0.221	0.212	0.205	0.199
Operating capacitance				μF/km	0.15	0.17	0.18	0.19	0.21	0.24
Charging current				A/km	10.9	12.2	13.0	13.7	15.2	17.4

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	690	756	804	943	1039	1095
			Flat	0.15m	A	640	692	728	836	909	951
		Open	Flat	0.15m	A	731	812	872	1031	1133	1206
			Flat	0.45m	A	829	935	1014	1224	1379	1505
	In buried ducts	Closed	Flat	0.30m	A	586	624	650	720	771	797
		Open	Flat	0.30m	A	750	843	911	1094	1225	1327
	In air	Closed	Trefoil	touching	A	962	1089	1179	1424	1613	1751
		Closed	Flat	0.15m	A	952	1058	1131	1276	1421	1506
		Open	Flat	0.15m	A	1095	1265	1390	1712	1974	2200
Copper	In ground	Closed	Trefoil	touching	A	832	910	958	1051	1128	1175
			Flat	0.15m	A	748	793	823	884	929	951
		Open	Flat	0.15m	A	905	1043	1117	1241	1334	1412
			Flat	0.45m	A	1039	1219	1320	1517	1683	1848
	In buried ducts	Closed	Flat	0.30m	A	664	706	727	778	819	839
		Open	Flat	0.30m	A	939	1096	1183	1349	1486	1617
	In air	Closed	Trefoil	touching	A	1177	1352	1454	1642	1816	1951
		Closed	Flat	0.15m	A	1119	1251	1321	1617	1552	1630
		Open	Flat	0.15m	A	1369	1646	1807	2113	2399	2684

Maximum permissible short-circuit currents for short circuit duration of one second

		800	1000	1200	1600	2000	2500
Aluminium conductor	kA	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	31.8	31.8	31.8	31.8	31.8	31.8

Sample constructions

Rated voltages:
U_0/U = 230/400 kV
U_m = 420 kV
U_p = 1425 kV

420kV cables 230/400kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor				mm²	800	1000	1200	1600	2000	2500
Constructional data										
Outer diameter	With aluminium conductor			mm	110	114	117	129	134	139
	With copper conductor			mm	114	120	125	130	135	139
Net weight	With aluminium conductor			kg/m	22.6	24.7	26.1	27.4	28.4	30.2
with Pb sheath	With copper conductor			kg/m	27.9	31.3	32.1	36.5	40.9	46.4
Minimum bending radius during cable laying				m	2.9	3.0	3.2	3.3	3.4	3.5
Electrical properties at 220kV and 50 Hz										
Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0367	0.0291	0.0247	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0493	0.0403	0.0352	0.0242	0.0196	0.0168
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0221	0.0176	0.0151	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0317	0.0233	0.0203	0.0158	0.0133	0.0113
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.185	0.188	0.188	0.184	0.185	0.187
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.133	0.126	0.121	0.117	0.112	0.108
(approx.)		Flat	0.15m	Ω/km	0.159	0.148	0.144	0.136	0.130	0.124
		Flat	0.30m	Ω/km	0.187	0.174	0.170	0.163	0.157	0.151
	Metallic sheath open	Flat	0.15m	Ω/km	0.167	0.157	0.152	0.143	0.136	0.130
		Flat	0.30m	Ω/km	0.210	0.200	0.196	0.187	0.179	0.173
		Flat	0.45m	Ω/km	0.236	0.226	0.221	0.212	0.205	0.199
Operating capacitance				μF/km	0.15	0.17	0.18	0.19	0.21	0.24
Charging current				A/km	10.9	12.2	13.0	13.7	15.2	17.4

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing		800	1000	1200	1600	2000	2500
Aluminium	In ground	Closed	Trefoil	touching	A	682	748	795	933	1028	1083
			Flat	0.15m	A	633	684	720	827	899	941
		Open	Flat	0.15m	A	723	803	863	1020	1121	1193
			Flat	0.45m	A	820	925	1003	1210	1364	1488
	In buried ducts	Closed	Flat	0.30m	A	580	617	643	712	763	788
		Open	Flat	0.30m	A	742	834	901	1082	1212	1313
	In air	Closed	Trefoil	touching	A	958	1085	1174	1418	1607	1744
		Closed	Flat	0.15m	A	948	1054	1126	1271	1415	1500
		Open	Flat	0.15m	A	1091	1260	1384	1705	1966	2191
Copper	In ground	Closed	Trefoil	touching	A	823	900	948	1040	1116	1162
			Flat	0.15m	A	740	784	814	874	919	941
		Open	Flat	0.15m	A	895	1032	1105	1227	1319	1397
			Flat	0.45m	A	1028	1206	1306	1500	1665	1828
	In buried ducts	Closed	Flat	0.30m	A	657	698	719	770	810	830
		Open	Flat	0.30m	A	929	1084	1170	1334	1470	1599
	In air	Closed	Trefoil	touching	A	1172	1347	1448	1635	1809	1943
		Closed	Flat	0.15m	A	1115	1246	1316	1411	1546	1624
		Open	Flat	0.15m	A	1364	1639	1800	2105	2389	2673

Maximum permissible short-circuit currents for short circuit duration of one second

		800	1000	1200	1600	2000	2500
Aluminium conductor	kA	76.5	95.5	114.5	152.5	190.4	256.1
Copper conductor	kA	115.5	144.2	172.9	230.3	287.7	359.5
Metallic sheath	kA	31.8	31.8	31.8	31.8	31.8	31.8

Sample constructions

Rated voltages:
U_o/U = 290/500 kV
U_m = 550 kV
U_p = 1550 kV

550kV cables 290/500kV Single core, XLPE insulated high voltage power cables

Nominal cross-sectional area of conductor				mm²	1600	2000	2500

Constructional data

Outer diameter	With aluminium conductor			mm	131	142	147
	With copper conductor			mm	133	142	147
Net weight	With aluminium conductor			kg/m	32.1	34.1	36.2
with Pb sheath	With copper conductor			kg/m	40.5	45.2	51.2
Minimum bending radius during cable laying				m	3.4	3.6	3.7

Electrical properties at 66kV and 50 Hz

Aluminium	Max. DC-resistance	at 20°C		Ω/km	0.0186	0.0149	0.0127
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0242	0.0195	0.0168
Copper	Max. DC-resistance	at 20°C		Ω/km	0.0113	0.0090	0.0072
conductor	AC resistance	at 90°C, approx.		Ω/km	0.0158	0.0132	0.0113
DC-resistance of metallic sheath at 20°C approx.				Ω/km	0.184	0.185	0.187
Reactance	Metallic sheath closed	Trefoil	touching	Ω/km	0.119	0.115	0.111
(approx.)		Flat	0.15m	Ω/km	0.136	0.130	0.124
		Flat	0.30m	Ω/km	0.162	0.157	0.151
	Metallic sheath open	Flat	0.15m	Ω/km	0.143	0.136	0.130
		Flat	0.30m	Ω/km	0.187	0.179	0.173
		Flat	0.45m	Ω/km	0.212	0.205	0.199
Operating capacitance				μF/km	0.18	0.19	0.21
Charging current				A/km	16.5	17.7	18.9

Continuous current-carrying capacities

Conductor	Cables laid	Sheath circuit	Laying formation	Spacing				
Aluminium	In ground	Closed	Trefoil	touching	A	914	1007	1064
			Flat	0.15m	A	812	888	932
		Open	Flat	0.15m	A	995	1085	1149
			Flat	0.45m	A	1187	1337	1455
	In buried ducts	Closed	Flat	0.30m	A	703	755	782
		Open	Flat	0.30m	A	1058	1184	1281
	In air	Closed	Trefoil	touching	A	1403	1585	1718
		Closed	Flat	0.15m	A	1265	1411	1490
		Open	Flat	0.15m	A	1682	1927	2137
Copper	In ground	Closed	Trefoil	touching	A	1017	1091	1139
			Flat	0.15m	A	857	898	918
		Open	Flat	0.15m	A	1194	1271	1338
			Flat	0.45m	A	1471	1631	1786
	In buried ducts	Closed	Flat	0.30m	A	757	801	823
		Open	Flat	0.30m	A	1304	1434	1556
	In air	Closed	Trefoil	touching	A	1618	1786	1918
		Closed	Flat	0.15m	A	1407	1545	1619
		Open	Flat	0.15m	A	2077	2340	2607

Maximum permissible short-circuit currents for short circuit duration of one second

Aluminium conductor	kA	152.5	190.4	256.1
Copper conductor	kA	230.3	287.7	359.5
Metallic sheath	kA	31.8	31.8	31.8

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Using the tables

The electrical properties and continuous current ratings apply for lead sheathed cables with our standard sheath thickness. The thickness of the metallic sheath and/or cross section of the copper wires screen can be adjusted according to the required single phase short circuit rating.

Where loading is cyclic, an appreciable increase in current capacities may be justified. Refer to IEC Publication 60853 for a calculation of the cyclic ratings.

Impedances, such as positive and negative sequence impedances and zero sequence impedance are strongly dependant on the laying configuration, metallic sheath bonding and other conductive elements parallel to the cable route. Therefore these impedances are calculated according to each situation and confirmed via measurements on completion of circuit.

Selecting a power cable

Different kinds of power cable constructions are required to transport electrical energy from the power station to the consumer. The following factors are important when selecting a suitable cable construction:

- Maximum operating voltage
- Insulation level
- Frequency
- Load carried
- Daily load curve
- Magnitude and duration of possible overload currents phase-to-phase and phase-to-earth
- Connection between overhead and cable line (direct connection or via transformer)
- Insulation level of equipment (bare conductor insulators, arresters, etc.)
- Voltage drop
- Length of line
- Profile of line
- Mode of installation:
  - underground (ducted or non-ducted)
  - overground (if in a tunnel, the dimensions and mode of ventilation of the tunnel)
- Chemical and physical properties of the soil:
  - whether rocky, sandy, clayey or boggy; moist or dry
  - chemical agents liable to cause corrosion etc.
  - maximum thermal resistivity of the soil
- Maximum and minimum ambient air and soil temperatures, taking into account adjacent hot-water pipes and other factors liable to heat the cables
- Specifications and requirements that apply
- The cable should be economical to use; an optimum cross-sectional area can be calculated based on the capital costs of the cable and running costs incurred by the power losses in the cable.

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Voltages

Rated Voltage

The voltage which forms the basis for certain operating characteristics and test conditions is called the rated voltage and is denoted Uo/U where

U_0 = the rated r.m.s. power frequency voltage between each conductor and sheath or sheath for which cables and accessories are designed.

U = the rated r.m.s. power frequency voltage between any two conductors for which cables and accessories are designed.

Operating voltage

U_m = the maximum r.m.s. power-frequency voltage between any two conductors for which cables and accessories are designed.

This is the highest voltage that can be sustained under normal operating conditions at any time and at any point in a system (temporary voltage variations due to fault conditions excluded).

Relationship between U_0/U and Um in three-phase systems are prescribed in IEC standard 60183 and USA standard C-84.

Complete system supply

It is essential that the accessories and cables are type-tested together forming a complete system. We supply a full range of accessories and fittings for splicing and terminating as well as tools and equipment, with full installation instructions. We also provide planning and supervision of the overall system packages.

Standards

The cables described in this catalogue are standard designs, and most have a proven operational performance record. Construction and tests are in accordance with IEC publications where applicable.

Conductor types

The conductor sizes listed in the tables are the most commonly used types, as follows:

Copper: stranded wires up to 800mm^2, Milliken up to 2500mm^2.

Aluminium: solid up to 1200mm^2, Milliken up to mm^2

Prysmian conductor range (in mm^2) is as follows:

	Copper	Aluminium
Solid	-	240-2000
Stranded	185-1000	185-2000
Milliken	1000-2500	1600-2500

Circular Mils

In the American standards, the cross section area is expressed in Circular Mils Ac.

The relation between cross sections expressed in mm^2 and Circular Mils is

$$A = \frac{Ac}{1973.5}\,mm^2$$

Weights and dimensions

Weights, dimensions and data characteristics are approximate and appropriate only to the products and parameter referred to in this brochure.

Sheath marking

Our standard embossed or surface printed outer sheath marking on round cables lists the following:

- name of manufacturer
- type designation, cross-sectional area of conductor, rated voltage and year of manufacture
- continuous length marking every metre or every few feet

Example:

EYLKrvlwd 76/132kV 1x800 2009 134m

Laying information

Permissible minimum bending radius of power cables during laying:
- during pulling of power cables, the bending radius should not fall below the values listed in the tables
- in the case of single bends (placing cables in final position), the above values may be reduced to a minimum of 20 x cable outer diameter (Milliken and stranded conductors) or even 15 x cable outer diameter (solid conductors)

During laying of power cables, particular attention must be paid to the permissible tensile force, as follows:
- permissible tensile forces when using cable pulling grips:
  $F = 2 \times D^2$ in N for cables with copper wire sheath
  $F = 2 \times D$ in N for cables with sheath.

D represents the cable outer diameter expressed in mm
- maximum recommended tensile forces when pulling eye is attached to the conductor:
  Alu stranded: $F = A \times 30\ N/mm^2$
  Alu solid: $F = A \times 20\ N/mm^2$
  Alu Milliken: $F = A \times 30\ N/mm^2$
  Cu stranded: $F = A \times 50\ N/mm^2$
  Cu Milliken: $F = A \times 80\ N/mm^2$

A represents the cross-sectional area of conductor expressed in mm^2.

Permissible minimum cable temperature during laying:
- With PVC outer sheath: - 5 °C
- With PE outer sheath: -10 °C

At lower temperatures, the cables must be adequately warmed up beforehand. This can be done by storing the cables in a heated room for at least 24 hours or by using special equipment.

Resistances

Direct current resistance

The maximum DC resistance values of conductors at 20 °C are listed in the cable standards. The DC resistance at other conductor temperatures may be calculated based on the following equation:

$$R = R_{20}\,[1 + \alpha_{20}\,(T - 20\ ^\circ C)]$$

R = DC resistance at temperature t, Ω/km
R_{20} = DC resistance of cond. at 20 °C, Ω/km
T = temperature of conductor, °C
α_{20} = temperature coefficient of the resistance at 20 °C, 1/ °C
for copper: $\alpha_{20} = 0.00393$
for aluminium: $\alpha_{20} = 0.00403$
for lead: $\alpha_{20} = 0.00400$

In the previous tables are given:
- Maximum DC resistance of conductors at 20 °C (in accordance with IEC60228)
- Calculated DC resistance of metallic (lead) sheath at 20 °C

Effective resistance

The effective resistance (= alternating current resistance) is made up of the DC resistance and the extra resistance, which takes into account additional losses caused by the current displacement in the conductor (skin effect, proximity effect).

In the tables, the effective resistance given for the conductors at maximum conductor temperature is based on the following presumptions:
- Frequency 50 Hz
- Closed sheath circuit
- Close trefoil formation

Inductance

The inductances can be calculated for the various laying configurations using the following equation:

$$L = \frac{X}{2 \cdot \pi \cdot f}$$

L = inductance, mH/km
X = reactance, ohm/km
f = system frequency, Hz

Operating capacitance, charging current and earth-fault current

The values for the operating capacitance of the cables are average values based on measurements and calculations. The values for the charging current are valid at a temperature of 20 °C, at a frequency of 50 Hz and at the rated voltage for the cable. The capacitance, charging current and earth-fault current values will not change when using XLPE insulated cables where the temperature rises from 20 °C to the maximum permissible continuous conductor temperature.

Continuous Current-carrying Capacity

A separate group of three single core cables can be continuously loaded according to the tables if the presumptions below are applied. Correction factors for other installations are given in Tables 1 to 7. The current-carrying capacities are calculated in accordance with the formula given in IEC Document 60287 and based on the following presumptions:

Presumptions

- On three-phase group of single core cables
- Maximum permissible temperature of inner conductor in continuous use:
- XLPE insulated cables – 90 °C
- Ambient air temperature – 35 °C
- Ground temperature – 25 °C
- Depth of laying of cables – 1 m
- Thermal resistivity of soil – 1.2 K.m/W
- Overground cables: naturally ventilated and solar radiation protected
- Open sheath circuit in single core cable group: circuit of metal sheaths, concentric conductors or metallic sheaths connected to each other and earthed at one point only = sheath bonded at single point. In addition, sheath circuit is considered open when cross-bonded at equal intervals.
- Closed sheath circuit in single core cable group = circuit of metal sheaths, concentric conductors or metallic sheaths connected to each other at both ends of the group and earthed at least at both ends = sheaths are solid bonded.

XLPE-insulated cables buried directly in ground

XLPE-insulated cables can be continuously loaded to a conductor temperature of 90 °C. In underground installations, if a cable in the ground is continuously operated at this highest rated conductor temperature, the thermal resistivity of the soil surrounding the cable may in the course of time increase from its original value as result of the drying-out processes. In consequence, the conductor temperature may greatly exceed the highest rated value with an unchanged cable load.

A temporary overload conductor temperature of 105 °C is allowable, but should be evaluated on a case-by-case basis

Short-circuit current capacity

When planning cable installations, care must be taken to ensure that the selected cables and fittings are capable of withstanding the expected dynamic and thermal short-circuit stresses.

The dynamic stresses depend on the maximum asymmetric short-circuit current, whereas the thermal stresses depend on the mean short-circuit current.

Thermal stresses

In the previous tables, the maximum permissible short circuit currents for short-circuit durations of one
second and the values are based on the following presumptions:

- Before short circuit, the temperature of conductors = maximum permissible temperature of conductor in continuous use (i.e.: 90 °C)
- The maximum permissible temperature of a conductor in short circuit is 250 °C for XLPE insulated cables, and 210 °C for the metallic sheath.
- The permissible short circuit currents for a short-circuit duration of 0.2 to 5 seconds may be calculated by multiplying the value of the maximum permissible short-circuit current for a short-circuit duration of one second by the figure $1/\sqrt{t}$, whereas t is the duration of short-circuit in seconds

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If site conditions are different from the standard conditions that apply for calculating the cable ratings, correction factors should be applied to the tabulated values of current ratings.

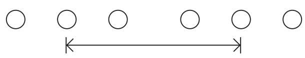
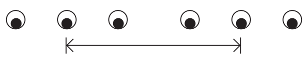
Rating factors for variations in ground temperature

Ground temperature °C	15	20	25	30	35	40	45
Rating factor	1.07	1.04	1.00	0.96	0.92	0.88	0.83

Rating factors for variations in ambient air temperature

Air temperature °C	20	25	30	35	40	45	50
Rating factor	1.14	1.10	1.05	1.00	0.95	0.90	0.84

Rating factors for variations in thermal resistivity of soil and number of groups for single core cables

	Axial separation of groups	Thermal resistivity of soil K.m/W	Number of groups			
			1	2	3	4
Cables in trefoil touching formation, laid direct in ground. Axial separation of groups 0.35m. Solid bonded sheaths.		0.9	1.13	0.93	0.81	0.75
		1.2	1.00	0.82	0.71	0.65
		1.5	0.91	0.74	0.63	0.59
		1.8	0.84	0.68	0.58	0.53
		2.1	0.78	0.63	0.54	0.49
		2.4	0.73	0.59	0.50	0.46
Cables in horizontal formation, laid direct in ground. Axial separation of cables 0.15m. Axial separation of groups 0.60m. Solid bonded and single point bonded sheaths.		0.9	1.12	0.97	0.86	0.82
		1.2	1.00	0.85	0.76	0.72
		1.5	0.91	0.77	0.68	0.65
		1.8	0.84	0.71	0.63	0.59
		2.1	0.78	0.66	0.58	0.55
		2.4	0.73	0.62	0.54	0.51
Cables in horizontal formation, laid direct in ground. Axial separation of cables 0.45m. Axial separation of groups 1.35m Single point bonded sheaths.		0.9	1.11	1.01	0.94	0.91
		1.2	1.00	0.91	0.83	0.81
		1.5	0.92	0.83	0.77	0.74
		1.8	0.85	0.76	0.70	0.68
		2.1	0.80	0.71	0.65	0.63
		2.4	0.75	0.67	0.61	0.59
Cables laid in single way ducts in ground. Horizontal axial separation of ducts 0.30m. Axial separation of groups 0.90m. Solid bonded and single point bonded sheaths.		0.9	1.09	0.96	0.90	0.86
		1.2	1.00	0.87	0.81	0.77
		1.5	0.93	0.80	0.73	0.70
		1.8	0.86	0.74	0.68	0.65
		2.1	0.81	0.69	0.64	0.61
		2.4	0.77	0.60	0.60	0.57

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